7 Session 5: Energy Analysis Tools

Energy Assessment and Analysis Using REEP

Presenter: Mr. Donald Fournier, University of Illinois, Urbana

Report Documentation Page

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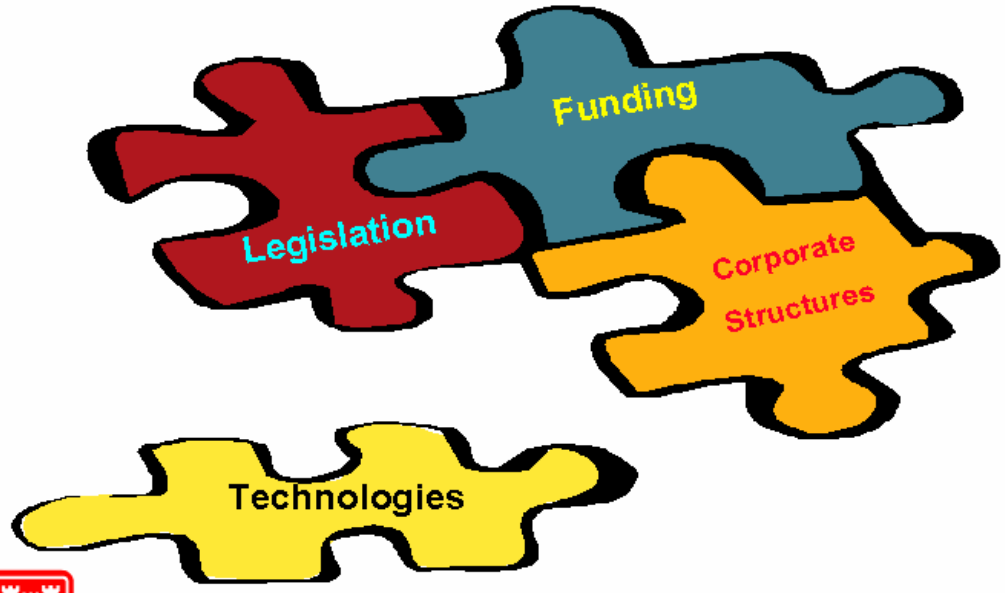
Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Managing Energy, Water and Pollution is a Big Challenge



US Army Corps of Engineers

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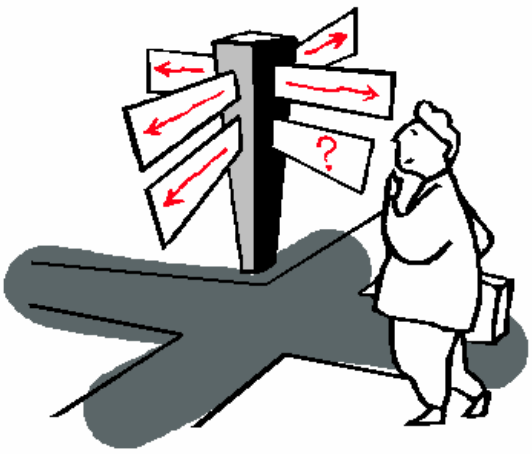
REEP provides Quick Answers to Tough Questions

Can I meet my savings target?

Where should I concentrate my efforts?

What will a project cost?

What if things change?



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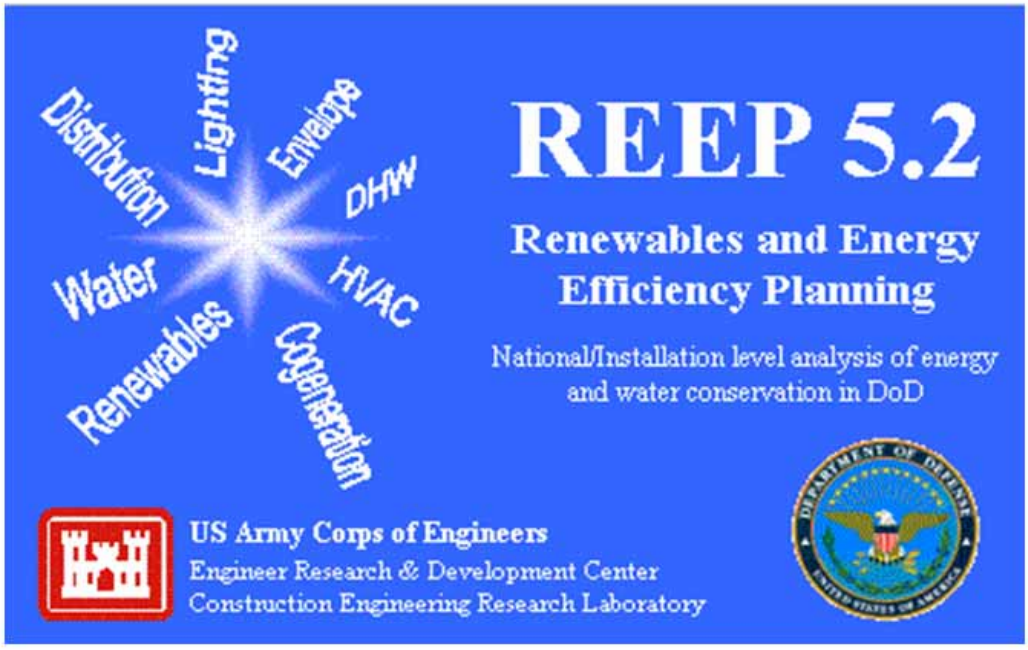
High Level Screening of Facilities Retrofits




Administrative
Community
Maintenance/
Production
Ten Facility Models
R&D
Storage
Barracks
Family Housing
Training
Hospital/Medical
Other
US Army Corps
of Engineers
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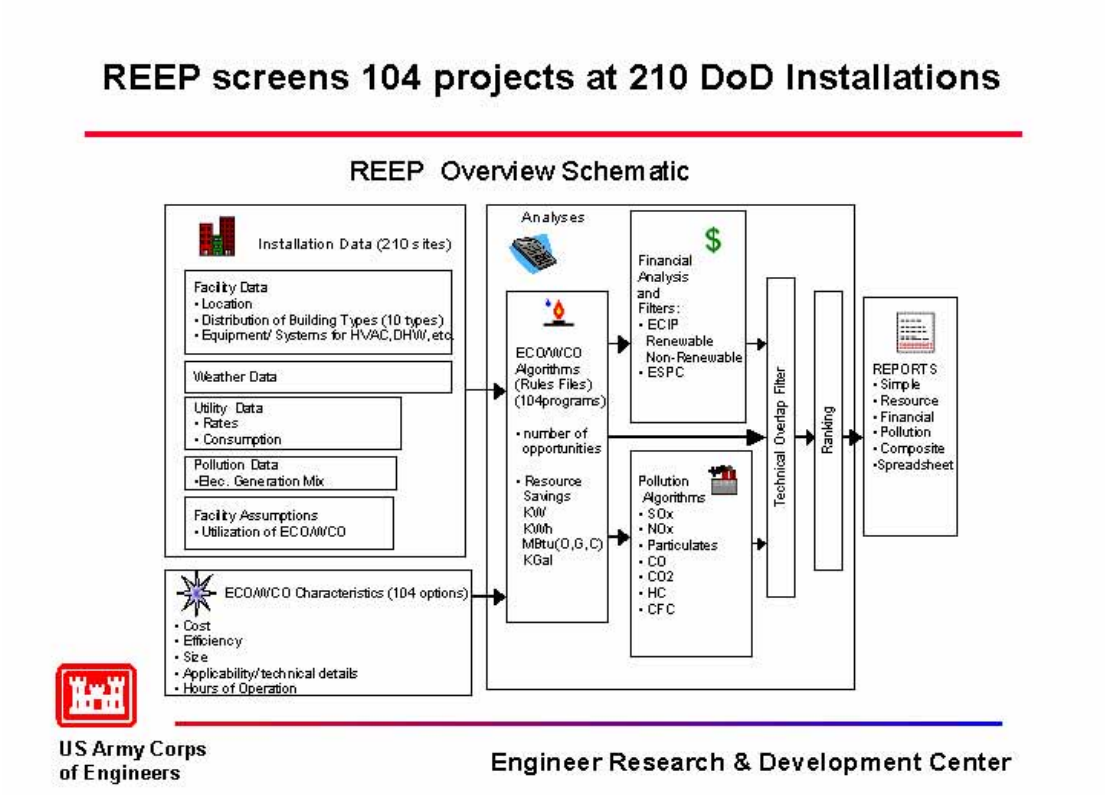
REEP screens 104 projects at 210 DoD Installations
REEP Overview Schematic
Installation Data (210 sites)
Facility Data
• Location
• Distribution of Building Types (10 types)
• Equipment/ Systems for HVAC, DHW, etc.
Weather Data
Utility Data
• Rates
• Consumption
Pollution Data
•Elec. Generation Mix
Facility Assumptions
• Utilization of ECO/W/CO
ECO/W/CO Characteristics (104 options)
• Cost
• Efficiency
• Size
• Applicability/technical details
• Hours of Operation
Analyses
ECO/W/CO
Algorithms
(Rules Files)
(104programs)
• number of
opportunities
• Resource
Savings
KW
KWh
MBtu(O,G,C)
KGal
Financial
Analysis
and
Filters:
• ECIP
Renewable
Non-Renewable
• ESPC
Pollution
Algorithms
• SOx
• NOx
• Particulates
• CO
• CO2
• HC
• CFC
Technical Overlap Filter
Ranking
REPORTS
• Simple
• Resource
• Financial
• Pollution
• Composite
•Spreadsheet
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Major Impact Analysis

- Resources (energy and water savings potential)
- Financial Viability (life cycle costing)
- Pollution Abatement Potential (CO_2, CO, SO_x, NO_x, PM,HC)
- Societal Costs
  - Program can optimize on any of the above
  - Overlapping Technologies compete based on chosen criteria
  - Parametric analysis capabilities

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Potential Users

- Federal Budget Analysts
- ACSIM
- IMAs
- DoD Energy Managers
- DoD Energy Contractors

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Preloaded data from 210 Installations

- 77 Army
- 73 Air Force
- 54 Navy
- 6 Marine

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REEP Analysis

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  ERDC-CERL
  Energy Branch
  e-westervelt@cecer.army.mil
  217-352-6511,x7522

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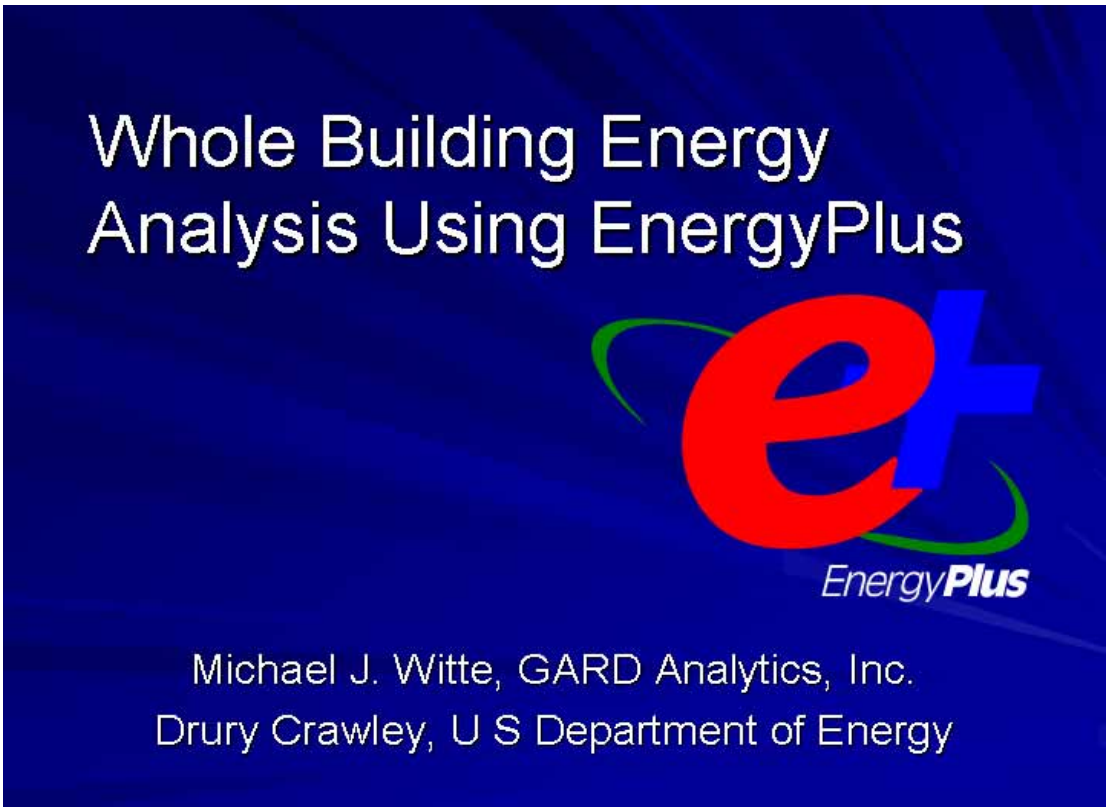
Whole Building Energy Analysis Using EnergyPlus

Presenter: Dr. Michael Witte, GardAnalytics.



Building Simulation Process: Overview and Resources

What is building simulation?

Software which emulates the ***dynamic interaction*** of heat, light, mass (air and moisture) and sound ***within the building*** to predict its ***energy and environmental performance*** as it is exposed to climate, occupants, conditioning systems, and noise sources

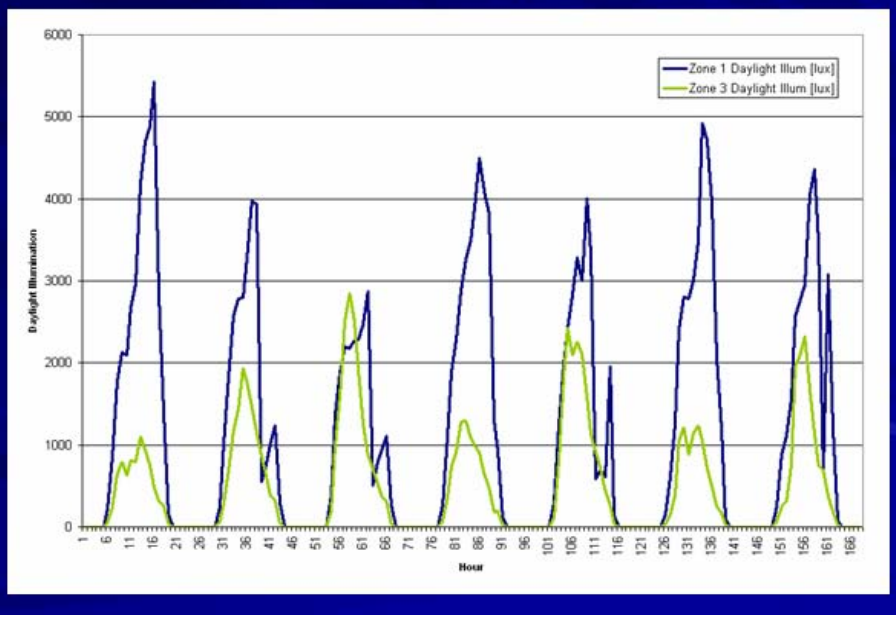
What kinds of programs are available

- Simplified programs for overall energy consumption assessment, peak temperature prediction, heating/cooling loads calculations
- Sophisticated programs, for hourly simulation of heat, light and air movement
- Complex specialist packages, for lighting, computational fluid dynamics (CFD), two- and three-dimensional conduction calculations
- Integrated design and analysis systems which combine a number of the above categories

What can building simulation programs do for me?

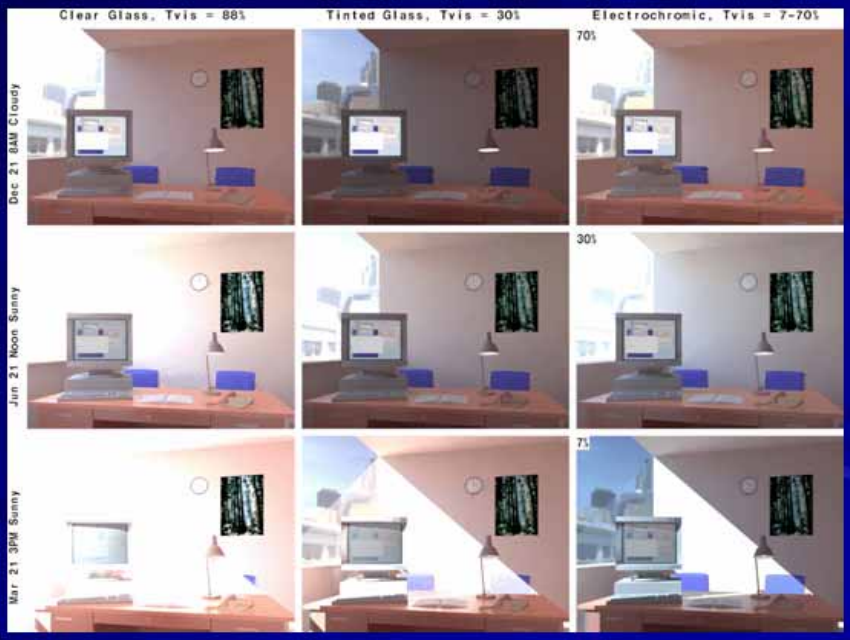
- Predict the dynamic response and performance of buildings
- Compare different design options—load calculations, energy performance, peak demand, and cost-benefit implications
- Simulate complex and 'green' technologies:
  - Naturally ventilated, passive and mixed-mode buildings
  - Daylighting
  - Overheating in unconditioned spaces
  - Advanced controls operation

Exploring Daylighting through Glazing Options

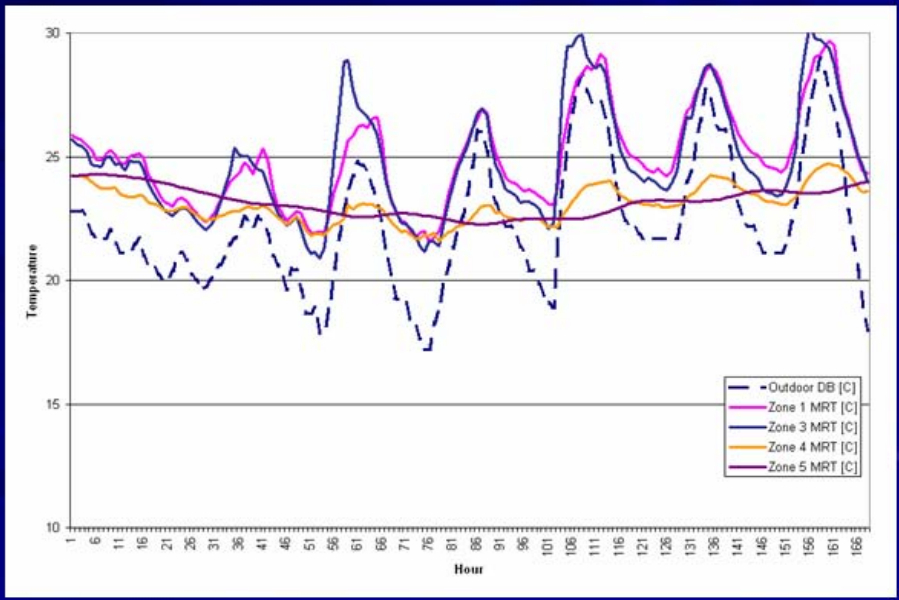


Change Glazing to Increase Daylight

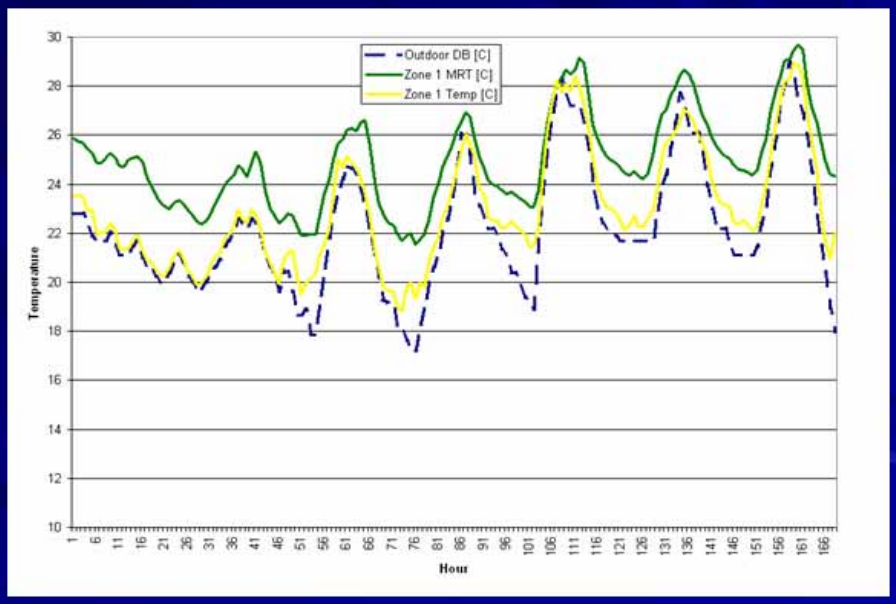
Glazing Studies of Glare



Thermal Comfort in Mixed-Mode Natural Ventilation



Overheating/Thermal Comfort



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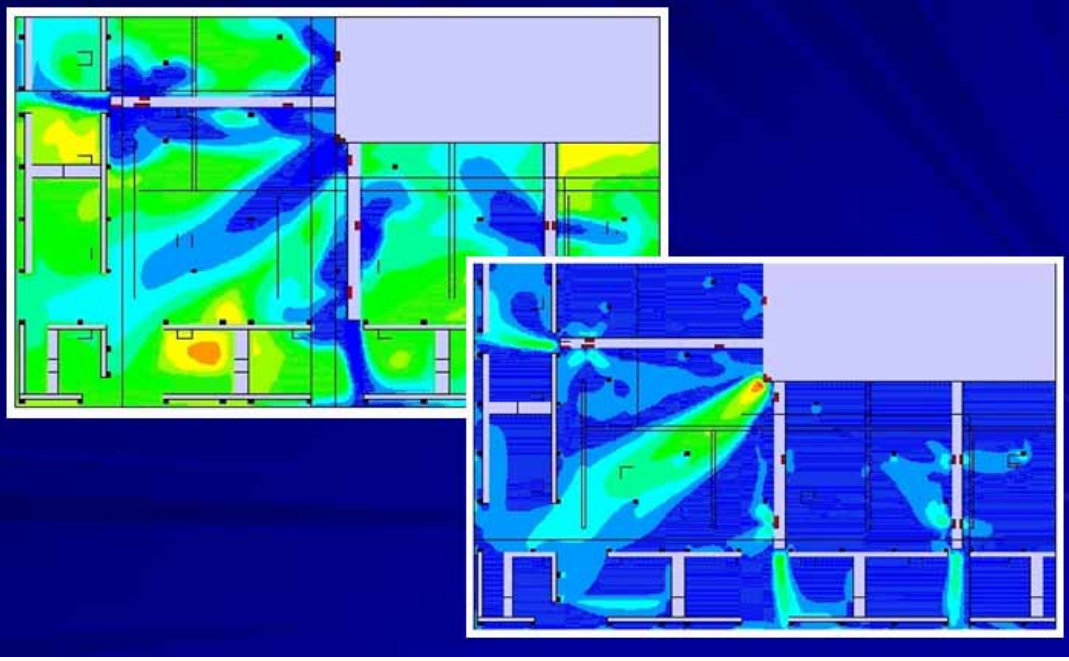
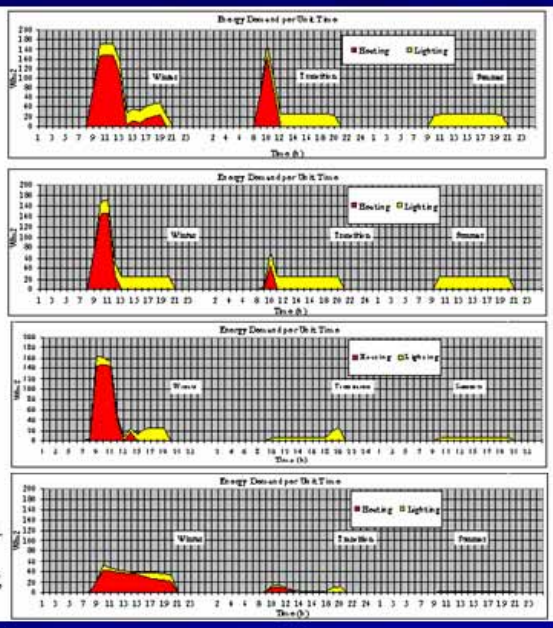


Comparison of Alternatives

- Base Case
- As above +
- advanced glazing
- As above +
- TIM wall +
- lighting control
- As above +
- efficient lighting +
- responsive heating



Annual Energy Performance

Heating:	118.29 kWh/m²a
Cooling:	0.00 kWh/m²a
Lighting:	100.10 kWh/m²a
Fans:	0.00 kWh/m²a
Small PL:	0.00 kWh/m²a
DHW:	0.00 kWh/m²a
Total:	**218.39 kWh/m²a**

Annual Energy Performance

Heating:	49.07 kWh/m²a
Cooling:	0.00 kWh/m²a
Lighting:	100.10 kWh/m²a
Fans:	0.00 kWh/m²a
Small PL:	0.00 kWh/m²a
DHW:	0.00 kWh/m²a
Total:	**149.17 kWh/m²a**

Annual Energy Performance

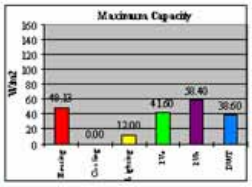
Heating:	64.52 kWh/m²a
Cooling:	0.00 kWh/m²a
Lighting:	41.59 kWh/m²a
Fans:	0.00 kWh/m²a
Small PL:	0.00 kWh/m²a
DHW:	0.00 kWh/m²a
Total:	**106.12 kWh/m²a**

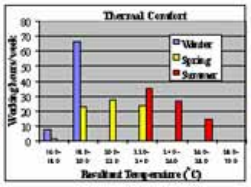
Annual Energy Performance

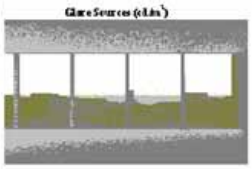
Heating:	48.99 kWh/m²a
Cooling:	0.00 kWh/m²a
Lighting:	19.96 kWh/m²a
Fans:	0.00 kWh/m²a
Small PL:	0.00 kWh/m²a
DHW:	0.00 kWh/m²a
Total:	**68.96 kWh/m²a**

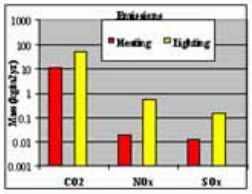
Integrated Performance

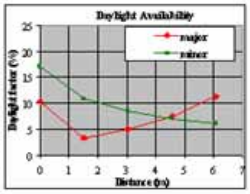
Viewing gallery with advanced glazing in all windows.
On/off lighting control, EE lighting.
TI wall.
PV hybrid + ducted wind turbines

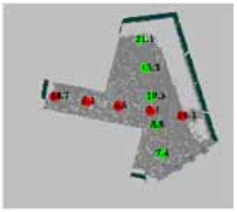


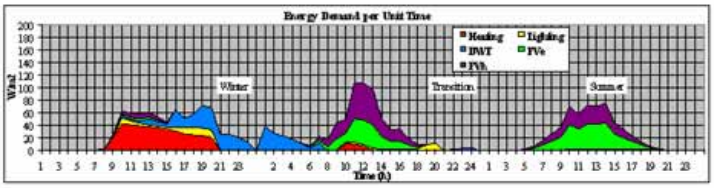












Annual Energy Performance

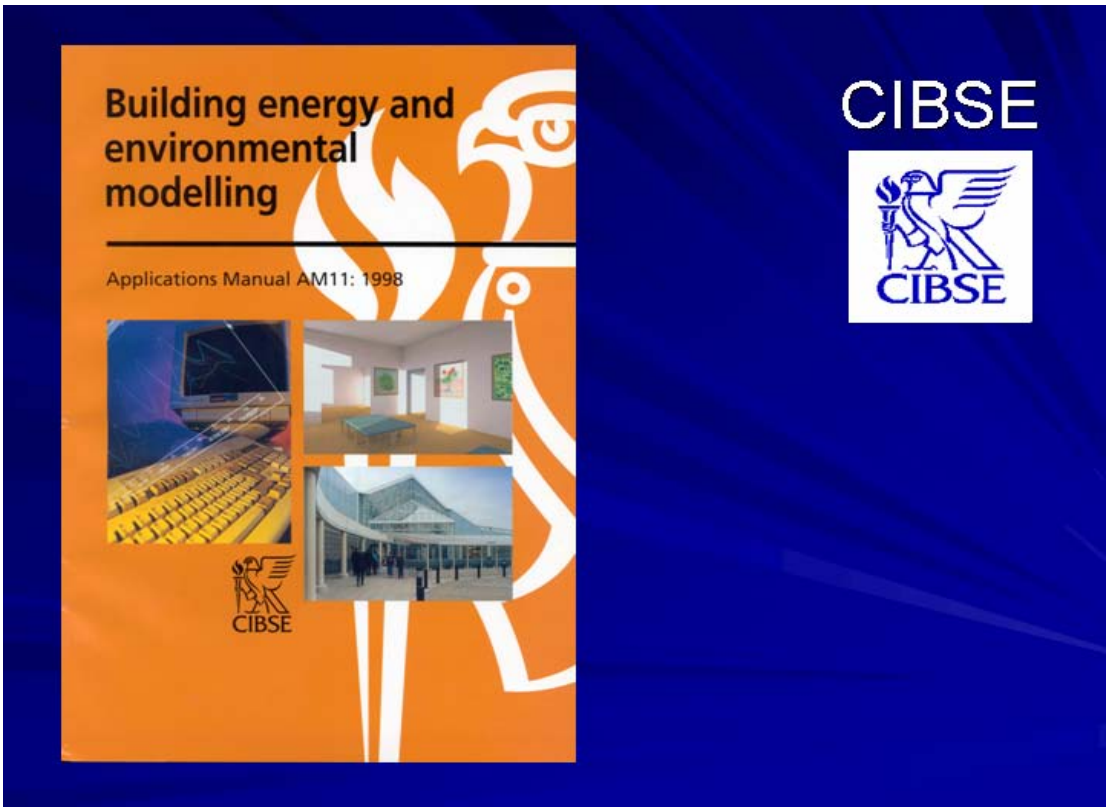
Heating:	48.99 kWh/m²a
Cooling:	0.00 kWh/m²a
Lighting:	19.96 kWh/m²a
Fans:	0.00 kWh/m²a
Total:	**68.96 kWh/m²a**
DWT	25.03 kWh/m²a
PVe	33.79 kWh/m²a
PVh	40.91 kWh/m²a

What Sort of Computer Do I Need?

- Most building energy simulation programs are available for the PC—although some are also available for Mac, Linux and Unix platforms.
- Typical PC will run the typical energy program without trouble.
- Run a variety of component and whole building energy simulation programs on a laptop—1 GHz processor with 256 MB memory and a 30 GB hard drive.

Where Can I Learn More?

- *ASHRAE 2001 Handbook of Fundamentals*, Chapter 31
  - Complexity of input
  - Quality of the output
  - Availability of weather data
  - Auxiliary capabilities
  - Availability of good support to answer questions
  - AND the broader issue of Choosing an Analysis Method
- *Building Energy and Environmental Modelling*, CIBSE Applications Manual 11:1998
- *ANSI/ASHRAE Standard 140-2001 Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs (*has the program been tested and are the results readily available?)



Sources of Hourly, Daily, and Monthly Weather Data

- TMY2 hourly data, typical weather years 239 US locations
- WYEC hourly data, typical weather years 72 US + 6 Canadian locations
- CWEC hourly data, typical weather years 55 Canadian locations
- IWEC hourly data, typical weather years 227 International locations

More Resources

- Technical Bulletin from TC 4.7 on *Estimating Building Energy Usage*
  - Available Energy Estimating Software Packages: www.energytoolsdirectory.gov
  - ANSI/ASHRAE Standard 140-2001
  - Sources of Hourly, Daily, and Monthly Weather Data
  - Sources of Bin Weather Data
- Find TC 4.7 on the web:
  www.mae.okstate.edu/tc47
  or under Technical Committees on the ASHRAE web site.

Web Resources: Building Energy Tools Directory

Information on more than 240 energy-related software tools for buildings from around the world

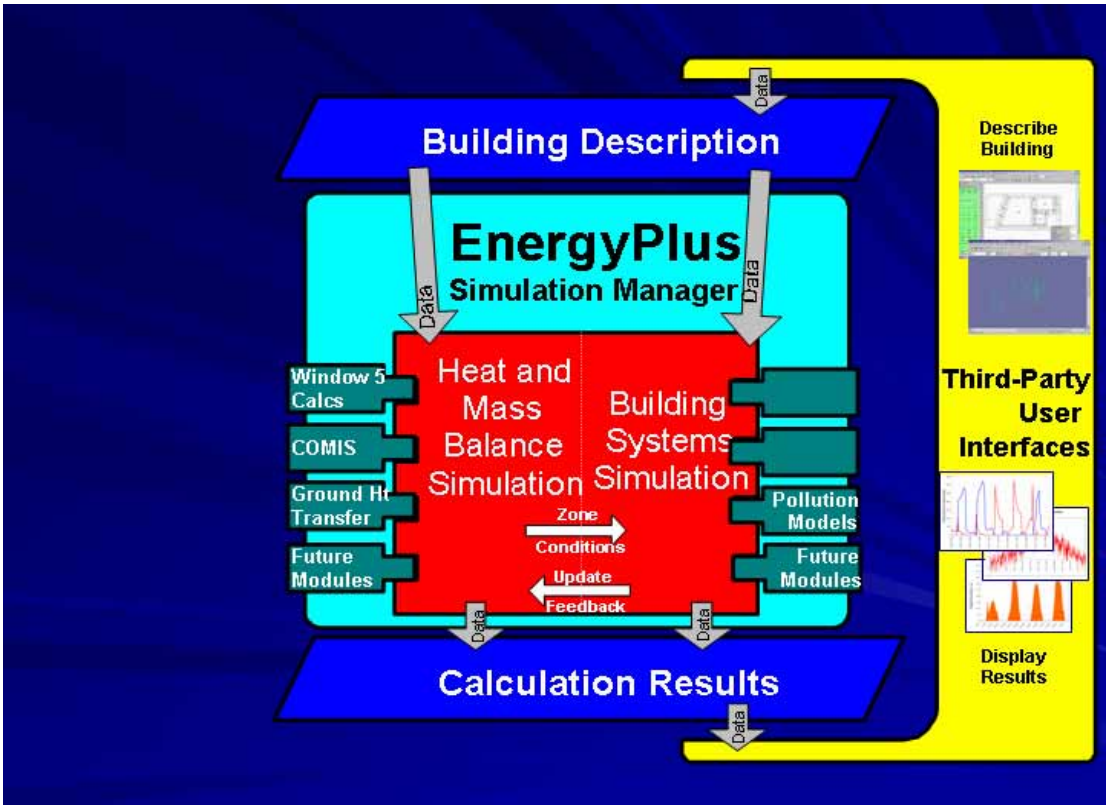
www.energytoolsdirectory.gov

EnergyPlus, A New Building Energy Simulation Program

- Best features/capabilities of BLAST and DOE-2
- New capabilities
- All-new software (Fortran 90)
- Input, output, and weather simpler than either DOE-2 or BLAST
- Launch, input editing (Windows) utilities available
- Simulation 'engine'—no user-friendly interface
- 8 graphical interfaces under development … first 2 betas available … release of several in next few months

EnergyPlus Major Concepts

- Heat (and mass) balance
- Simultaneous loads/building simulation
- Multiple time steps [loads 15 min. default, building systems variable]
- Simple input/output
- Modular code for easy expansion
- Number of surfaces, zone and system unlimited—computer memory and hard drive
- Link to other software for other capabilities



EnergyPlus Features

Concepts from IBLAST	Concepts from DOE-2	New Features
• Integrated simultaneous loads/HVAC solution • Multiple time steps • Heat balance • Interior convection and mass • Combined heat and mass transfer • Thermal comfort • Radiant heating and cooling • Atmospheric pollution calculation • System and plant models	• Input functions • Anisotropic sky model • Advanced fenestration (blinds, switchable glazing) • WINDOW 4 library • Daylighting and glare • Atmospheric pollution calculation • System and plant models	• User-definable reporting • Ground heat transfer • WINDOW 5 calculations • Multizone airflow • HVAC loops (air, water) • User-configurable object-based HVAC components • Electrical system • Photovoltaic models • Links to CAD

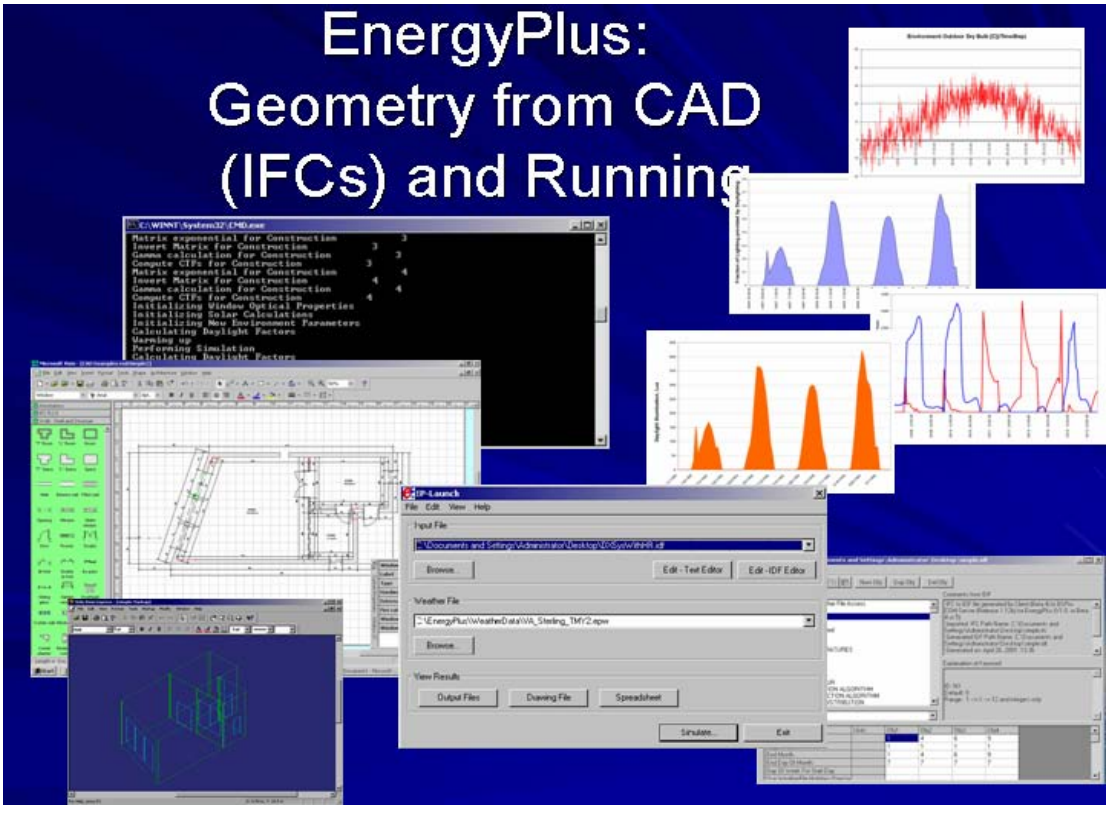
Cool New Stuff

- Fully Integrated Loads & HVAC Simulation
  (New ASHRAE Loads Calculation method)
- Occupant Comfort
- Moisture storage and release
- Mix and match equipment and systems
- Photovoltaic systems
- Green Buildings (example: natural ventilation, COMIS)
- Import geometry from CAD
- Lots more
  - Low and high temperature radiant heating
  - Supply air plenums

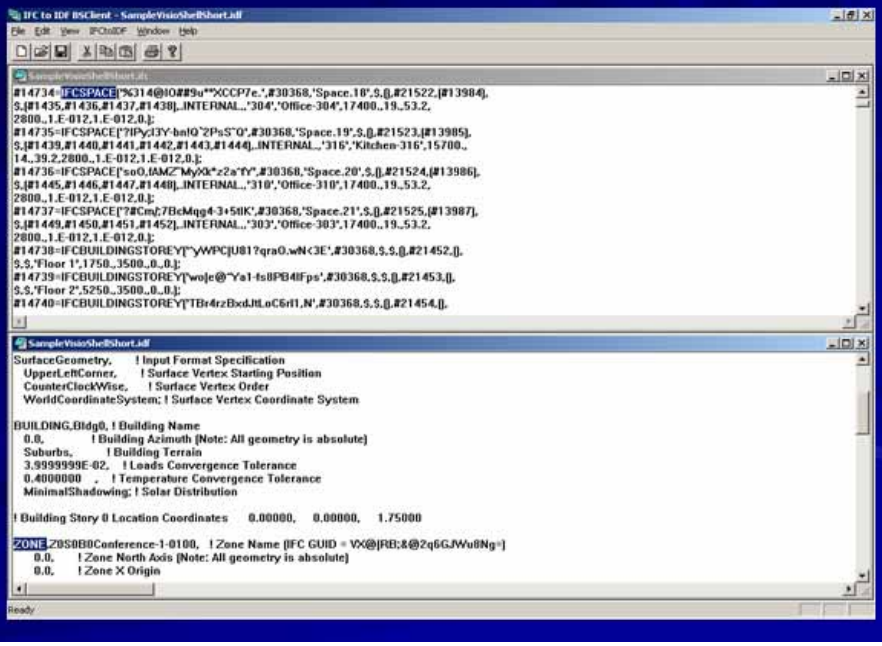
Under Development

- Displacement Ventilation (2004)
  - Have UF supply plenum, slab coupling, developing stratified zone model
  - Underfloor air distribution
- Cooled beams, cooled ceiling panels (2003)
- Heat recovery: more types, controls (2003)
- Site generation: more types (fuel cells, microturbines) (2004)
- Electric system simulation (2004)
- Duct loss (air and heat) (2004)
- Lots more!

EnergyPlus: Geometry from CAD (IFCs) and Running



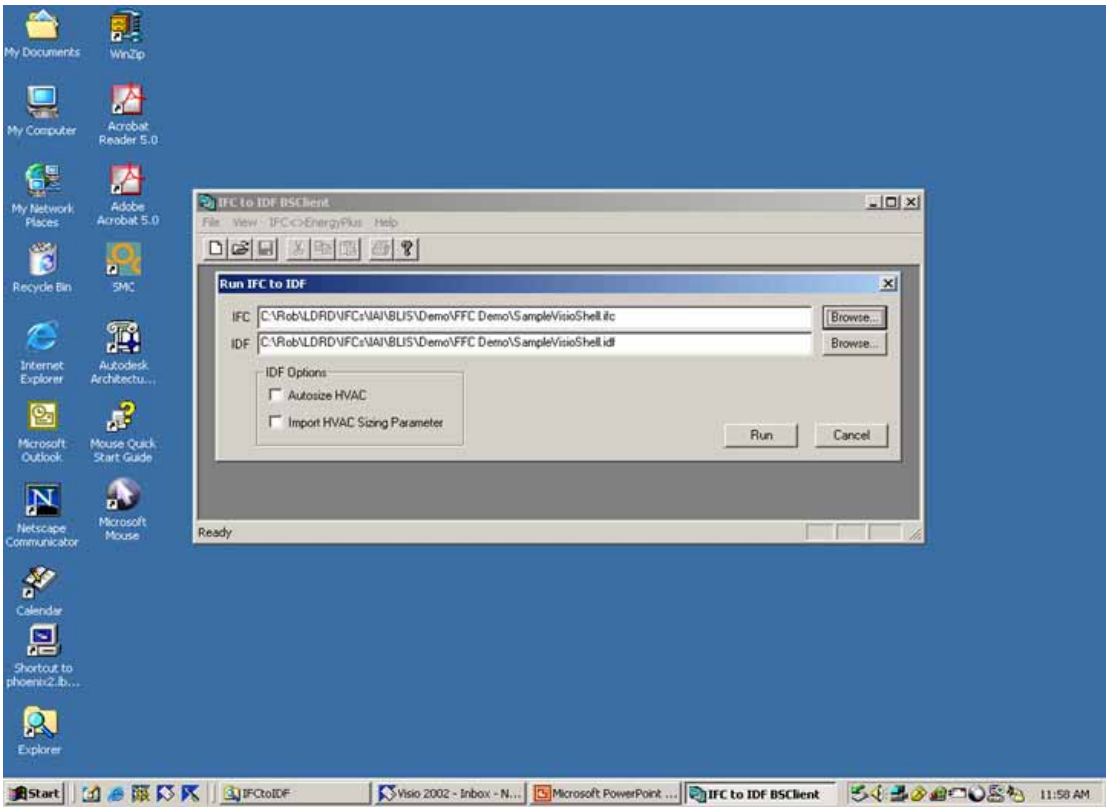
IFC to IDF Mapping



CAD Programs Supporting IFCs

http://www.bauwesen.fh-muenchen.de /iai/ImplementationOverview.htm

- **ArchiCAD**
  Graphisoft www.graphisoft.com
- **Architectural DeskTop (AutoCAD)**
  Autodesk www.autodesk.com
- **ALLPLAN FT**
  Nemetschek www.allplan-usa.com
- **Visio 2002 Technical** – *no longer supported*
  Microsoft


My Documents
WinZip
My Computer
Acrobat Reader 5.0
My Network Places
Adobe Acrobat 5.0
Recycle Bin
SMC
Internet Explorer
Autodesk Architectu...
Microsoft Outlook
Mouse Quick Start Guide
Netscape Communicator
Microsoft Mouse
Calendar
Shortcut to phoenix2.lb...
Explorer
IFC to IDF BSClient
File View IFC<->EnergyPlus Help
Run IFC to IDF
IFC C:\Rob\LDRD\IFCs\IAI\BLIS\Demo\FFC Demo\SampleVisioShell.ifc
IDF C:\Rob\LDRD\IFCs\IAI\BLIS\Demo\FFC Demo\SampleVisioShell.idf
Browse...
Browse...
IDF Options
Autosize HVAC
Import HVAC Sizing Parameter
Run
Cancel
Ready
Start
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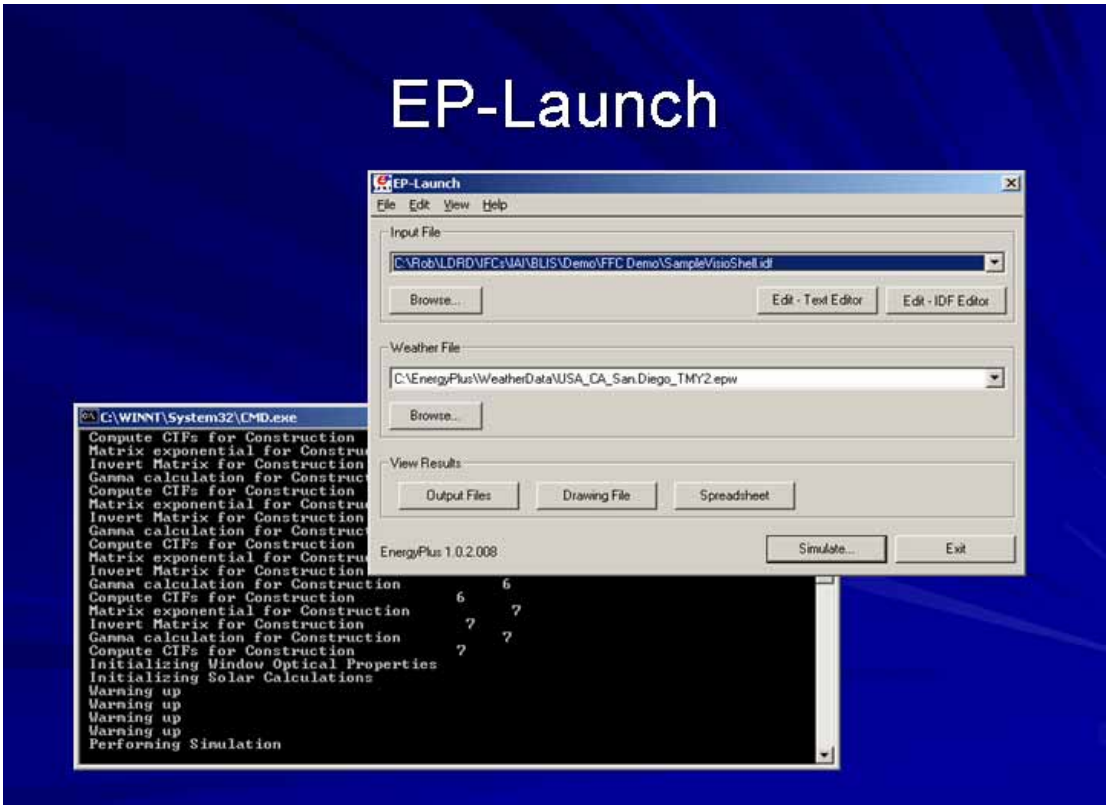
EP-Launch
EP-Launch
File Edit View Help
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Browse...
Edit - Text Editor
Edit - IDF Editor
Weather File
C:\EnergyPlus\WeatherData\USA_CA_San.Diego_TMY2.epw
Browse...
View Results
Output Files
Drawing File
Spreadsheet
EnergyPlus 1.0.2.008
Simulate...
Exit
C:\WINNT\System32\CMD.exe
Compute CTFs for Construction
Matrix exponential for Construction
Invert Matrix for Construction
Gamma calculation for Construction
Compute CTFs for Construction
Matrix exponential for Construction
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Gamma calculation for Construction
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Matrix exponential for Construction
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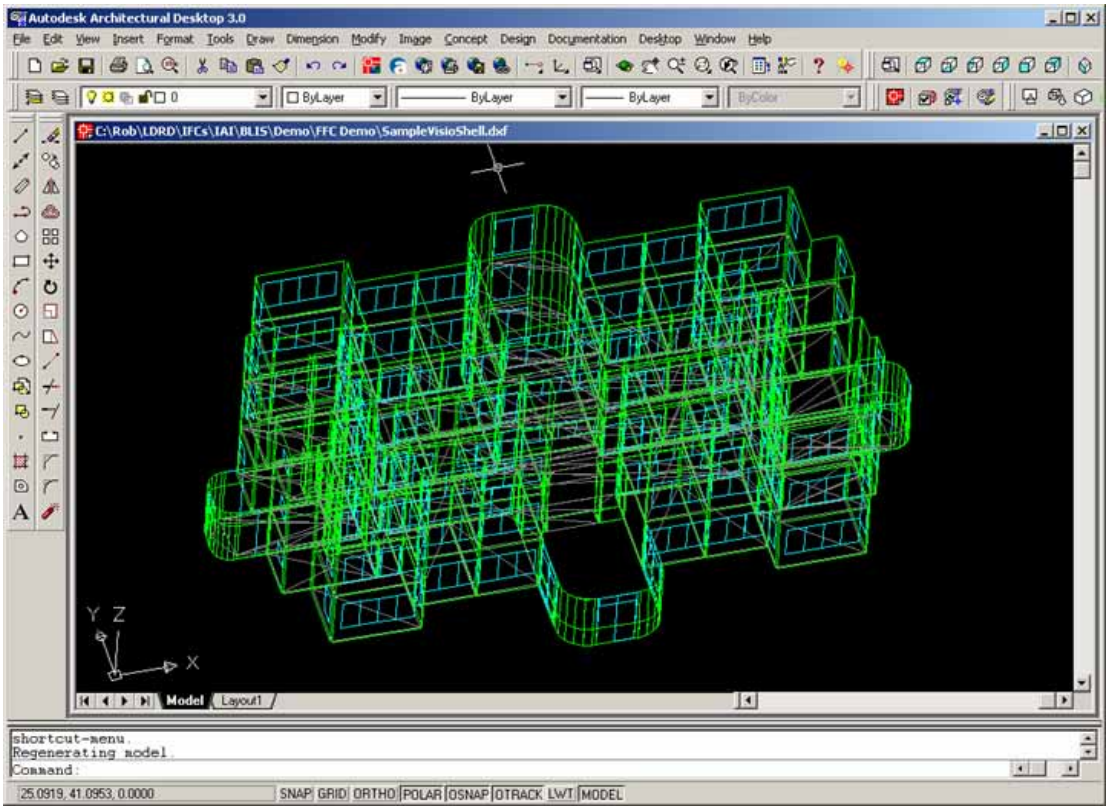
Initializing Window Optical Properties
Initializing Solar Calculations
Warming up
Warming up
Warming up
Warming up
Performing Simulation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Layout1
shortcut-menu
Regenerating model.
Command:
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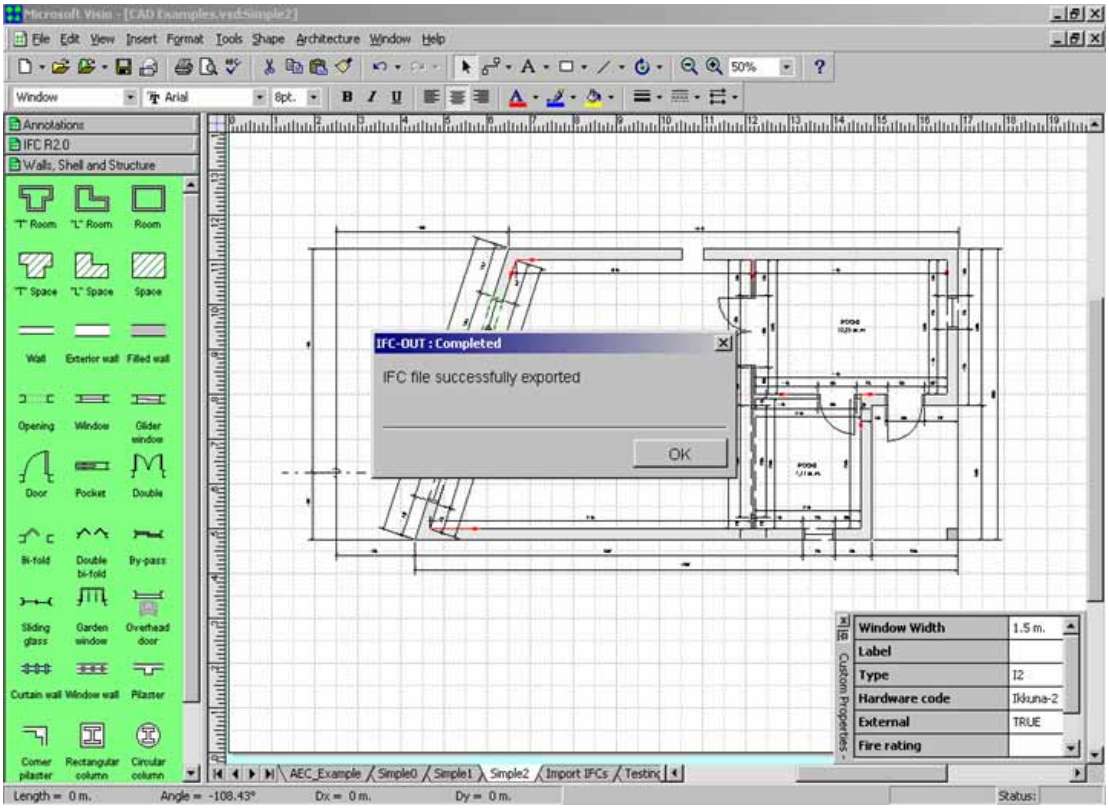
SNAP GRID ORTHO POLAR OSNAP OTRACK LWT MODEL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Annotations
IFC R2.0
Walls, Shell and Structure
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IFC file successfully exported
OK
Window Width 1.5 m.
Label
Type I2
Hardware code Ikkuna-2
External TRUE
Fire rating
AEC_Example Simple0 Simple1 Simple2 Import IFCs Testing
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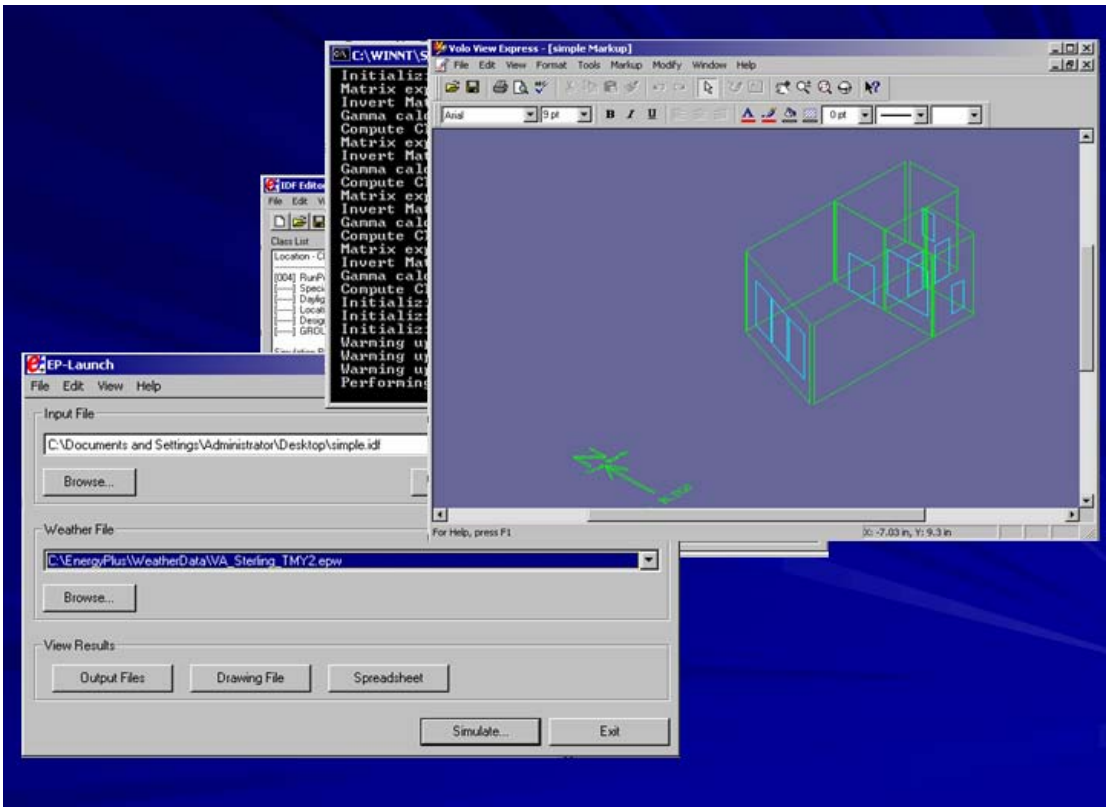
Status:


Volo View Express - [simple Markup]
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File Edit View Help
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Browse...
Weather File
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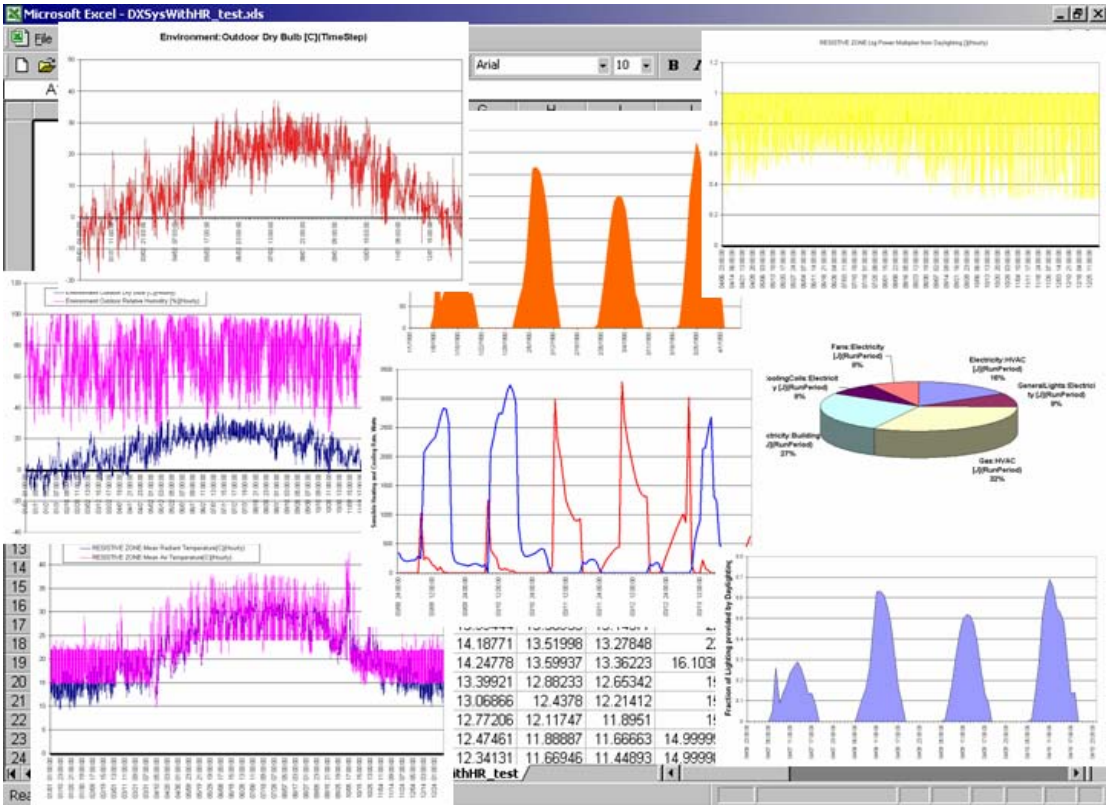
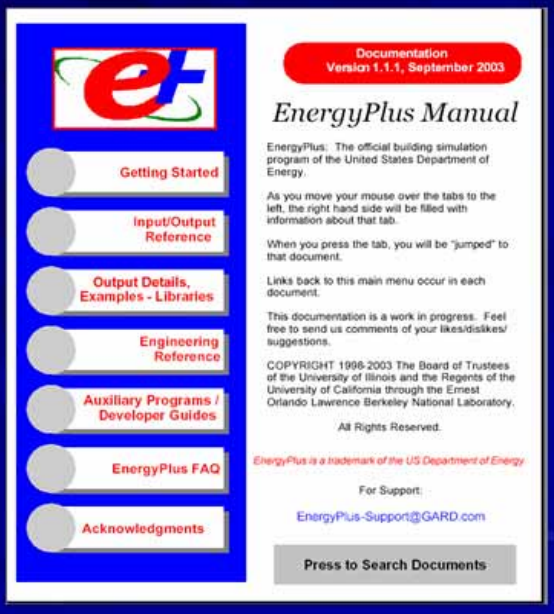
Browse...
View Results
Output Files
Drawing File
Spreadsheet
Simulate...
Exit


Microsoft Excel - DXSysWithHR_test.xls
Environment:Outdoor Dry Bulb [C](TimeStep)

EnergyPlus Documentation

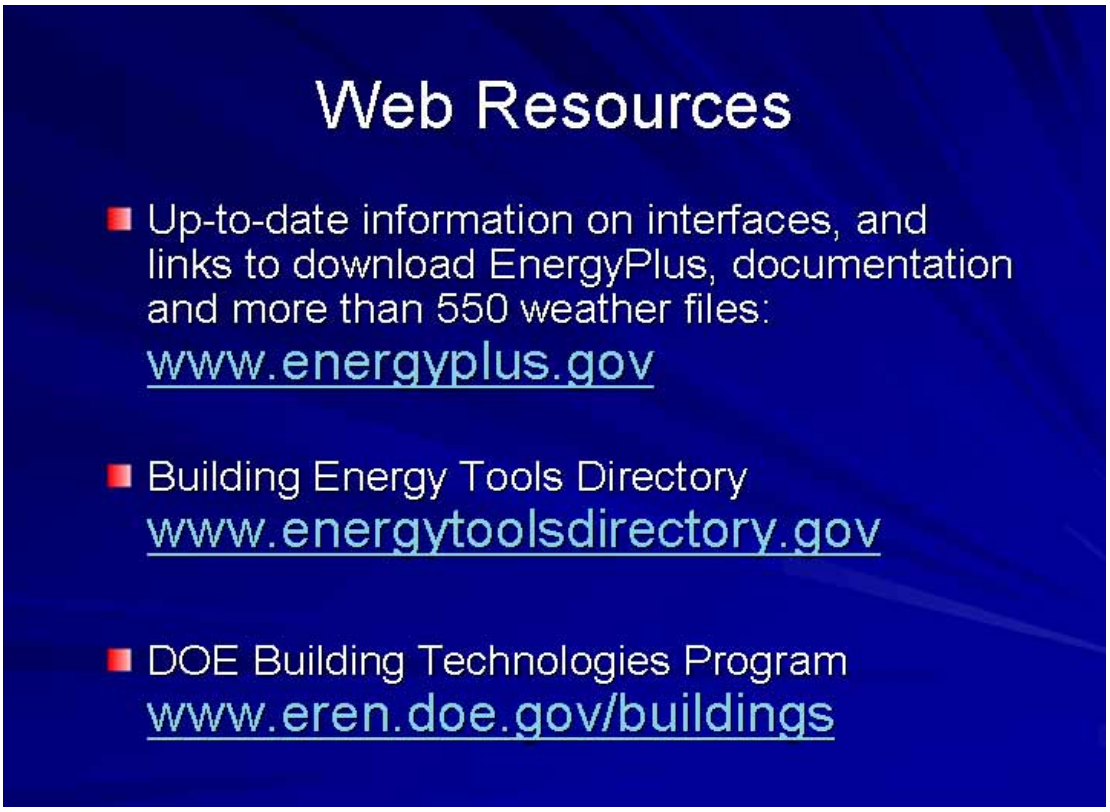
More than 1500 pages of input/output reference, examples and engineering documentation



EnergyPlus Summary

- Design focused on connectivity, extensibility, and maintainability
- Many new capabilities
- A calculation engine—no GUI interface—yet with a number of Window auxiliary programs: EPLaunch, IDFEditor, IFCtoIDF, Weather Converter
- Working with >50 module developers and 8 graphical interface developers
- Program, all documentation, and weather data for >550 locations available free of charge (web download)→

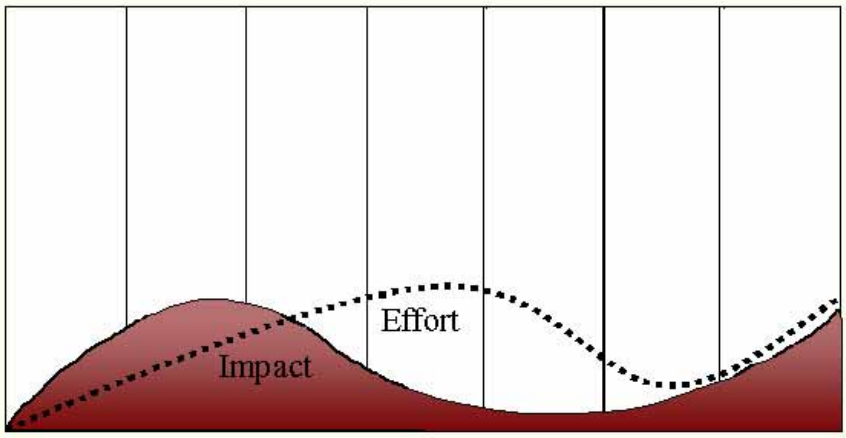
www.energyplus.gov


Web Resources
Up-to-date information on interfaces, and links to download EnergyPlus, documentation and more than 550 weather files:
www.energyplus.gov
Building Energy Tools Directory
www.energytoolsdirectory.gov
DOE Building Technologies Program
www.eren.doe.gov/buildings

A Pattern Approach to High Performance Buildings — E-Benchmark

Presenters: Mr. Jeff Johnson, New Building Institute and Ms. Abby Vogen, Energy Center of Wisconsin

Design Process



Advanced Buildings

- Performance Criteria
  - National beyond-code criteria
- Designers Manual
  - How to from design team perspective
- Owners Guide
  - What are the benefits to building to the E-Benchmark?
- Education
  - Education and program for design professionals

Focus on Delivering Performance

Performance Criteria

- Nationally recognized efficiency targets
  - Envelope
  - Mechanical
  - Lighting
  - Power (demand and renewables)
- Exemplar Processes
  - Integrated Design
  - Commissioning
  - Operations/Maintenance
- Two Approaches
  - Prescriptive "patterns"
  - Whole-building simulation

Education

- Building Science and Outcome based training program
- Four Modules
  - Integrated Design Primer
  - Envelope and Moisture
  - Mechanical and Controls
  - Lighting and Daylighting

Education Program

- To Be Completed

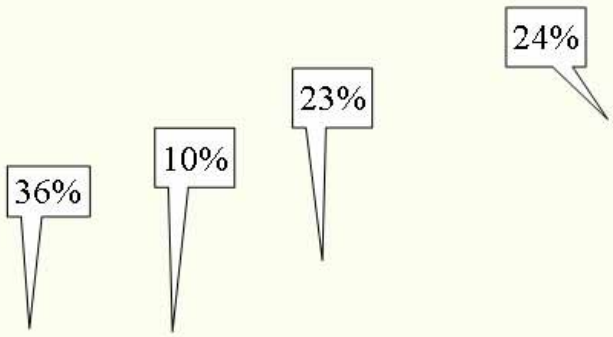
LEED Connections

- To be completed

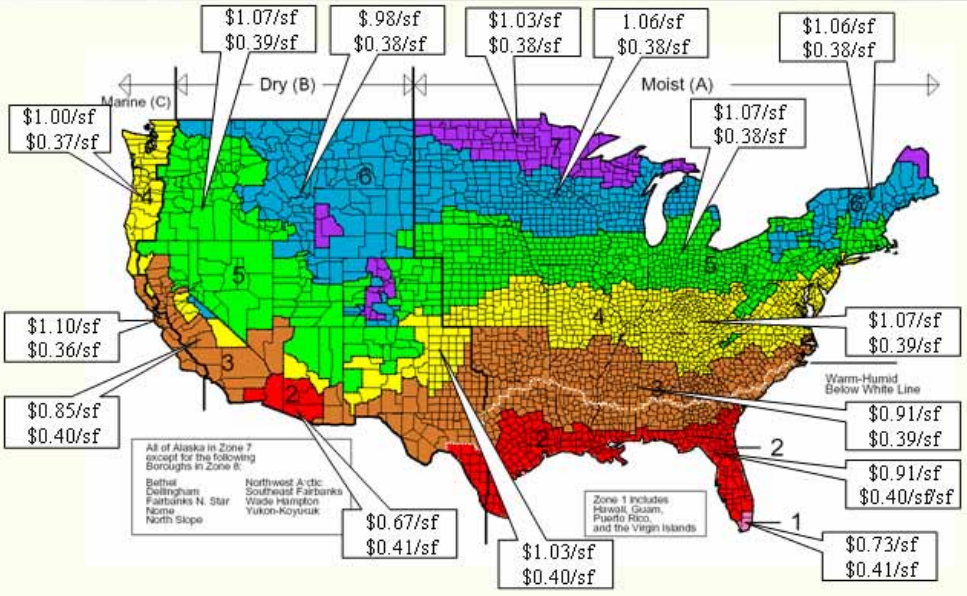
Impacts

- To Be Completed

Example - End-use Impacts

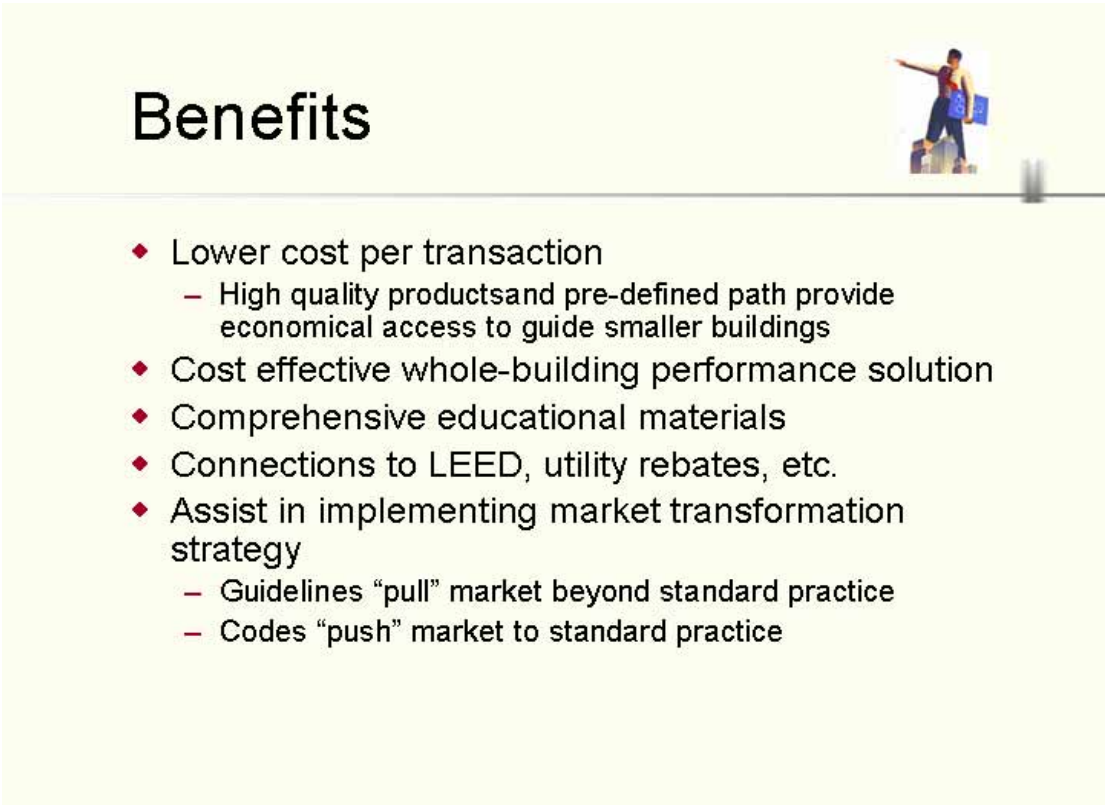


Example Cost/Benefit



Range of Impacts

- Costs
  - Ranges from $0.75 to $1.40/sf with supermarket up to $3.50/sf including commissioning
- Savings
  - Ranges from $0.20 to $0.80/sf with schools $0.10 to $0.15/sf
  - Electric savings at 4 to 8 kWh/sf
  - $0.01 to $0.03/kWh with schools up to $0.07
  - Ventilation benefits not included in cost savings
- Ventilation and Productivity
  - $154 to $280 per employee (CMU-BIDS)
  - Direct result of explicit process requirements



Retrofitting in Educational Buildings — Energy Concept Adviser for Technical Retrofit Measures

Presenter: Mr. Simon Wössner. Fraunhofer-Institut für Bauphysik. (Germany). IEA Energy Conservation in Buildings &Community Systems Program (ECBCS).

Energy Concept Adviser

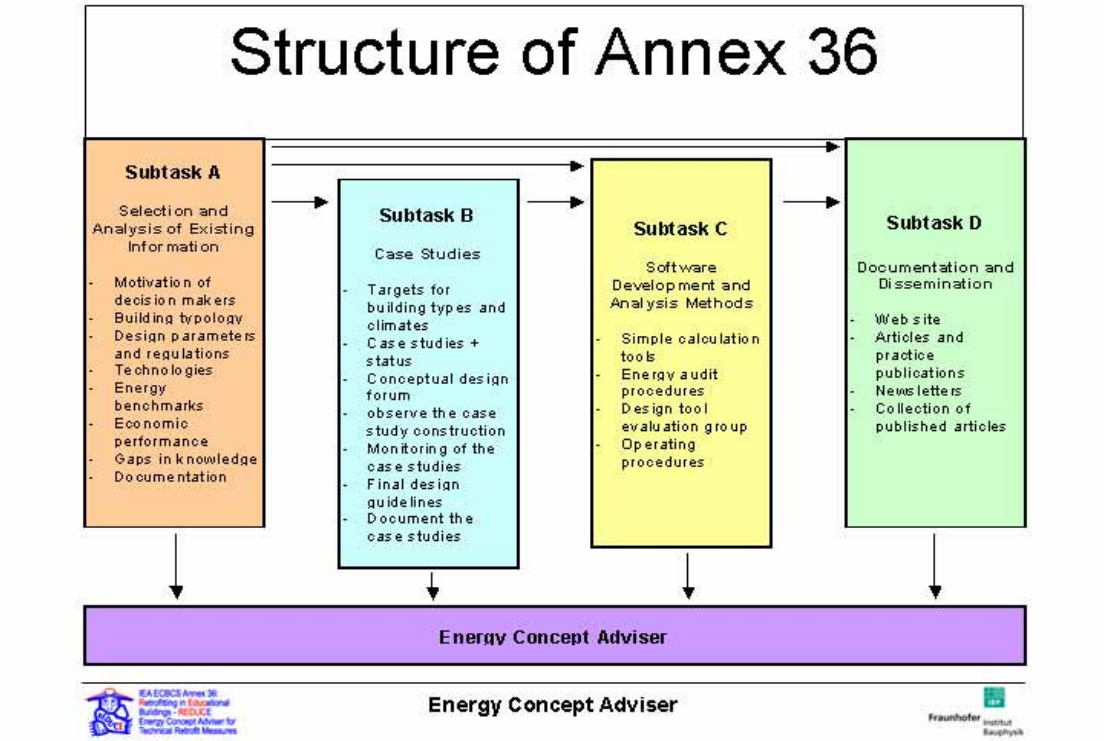
A New Internet-based Tool for Decission Makers and their Technical Staff

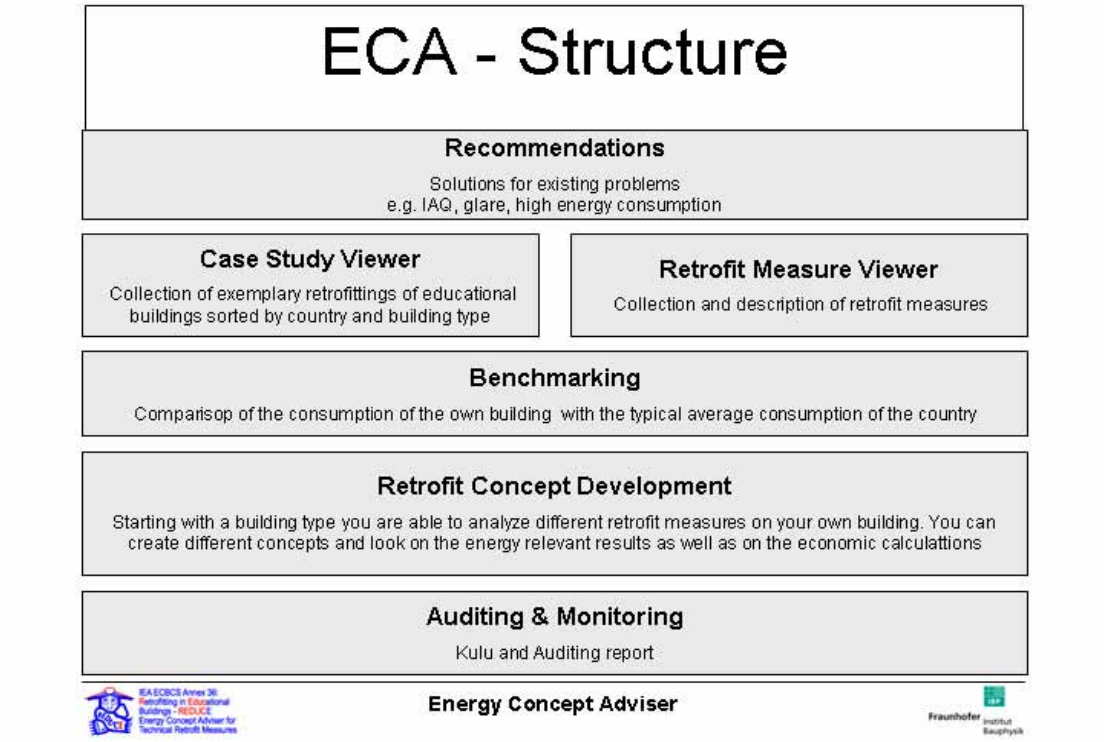
Dipl.-Ing. Simon Wössner

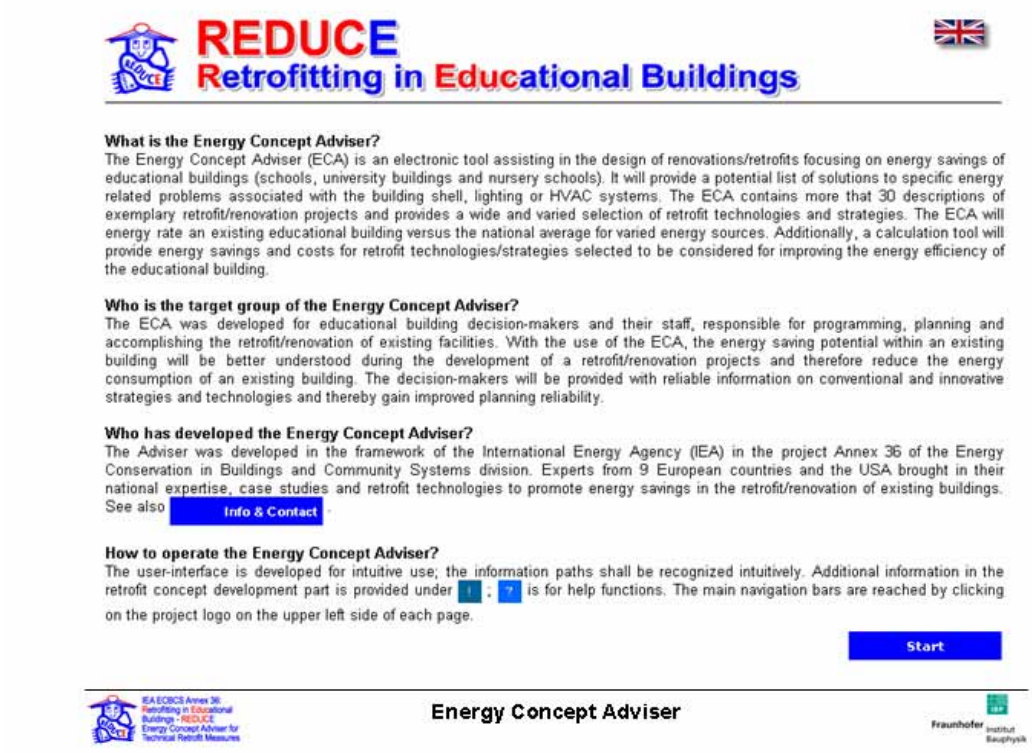
Fraunhofer Institut of Building Physics

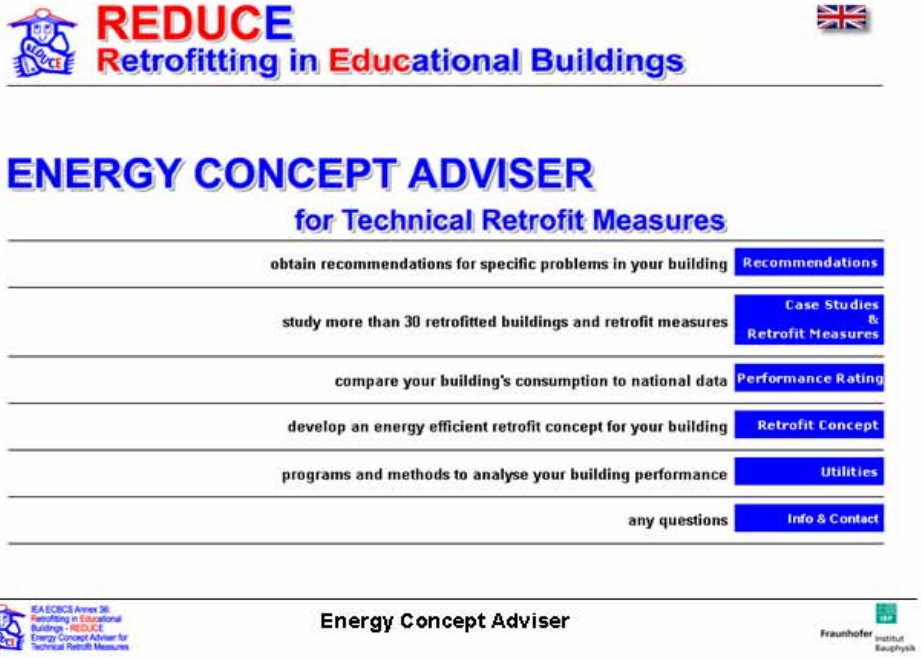
What were the reasons, why the Energy Concept Adviser was developed?

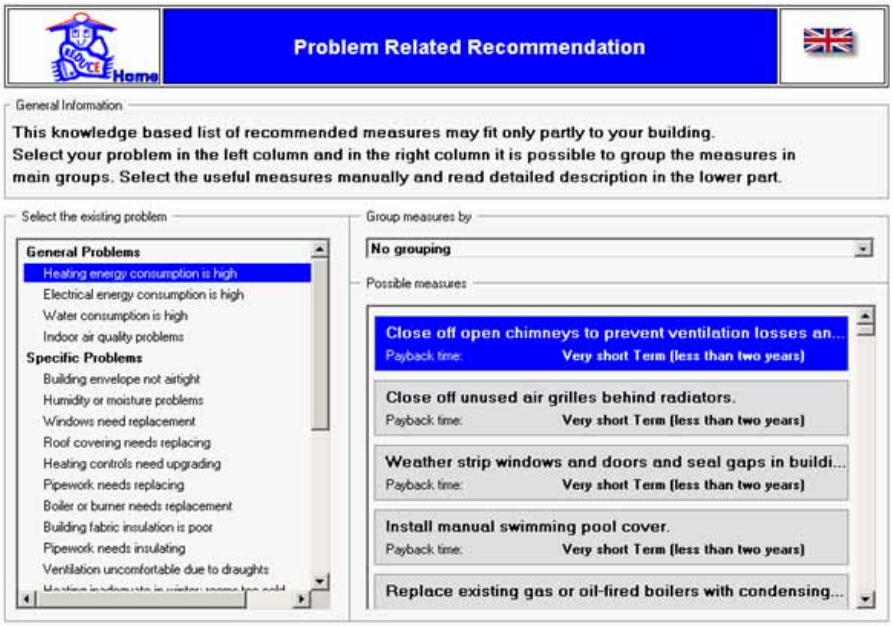
- high energy consumption in educational buildings (nursery schools, schools, universities,…)
- desicion makers are often not qualified enough informed
- many different factors for a high energy consumption
  building itself, heating system, ventilation, lighting, controls, (cooling)
- an estimation of investment costs and the potential of energy savings not possible without tools

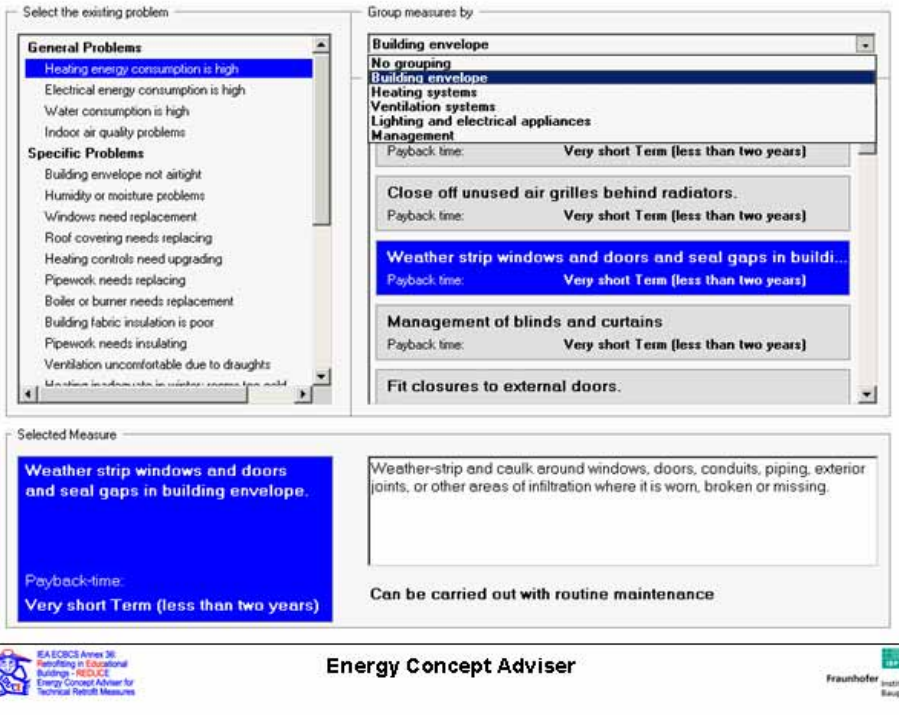

Structure of Annex 36
Subtask A
Selection and Analysis of Existing Information
- Motivation of decision makers
- Building typology
- Design parameters and regulations
- Technologies
- Energy benchmarks
- Economic performance
- Gaps in knowledge
- Documentation
Subtask B
Case Studies
- Targets for building types and climates
- Case studies + status
- Conceptual design forum
- observe the case study construction
- Monitoring of the case studies
- Final design guidelines
- Document the case studies
Subtask C
Software Development and Analysis Methods
- Simple calculation tools
- Energy audit procedures
- Design tool evaluation group
- Operating procedures
Subtask D
Documentation and Dissemination
- Web site
- Articles and practice publications
- Newsletters
- Collection of published articles
Energy Concept Adviser
Energy Concept Adviser

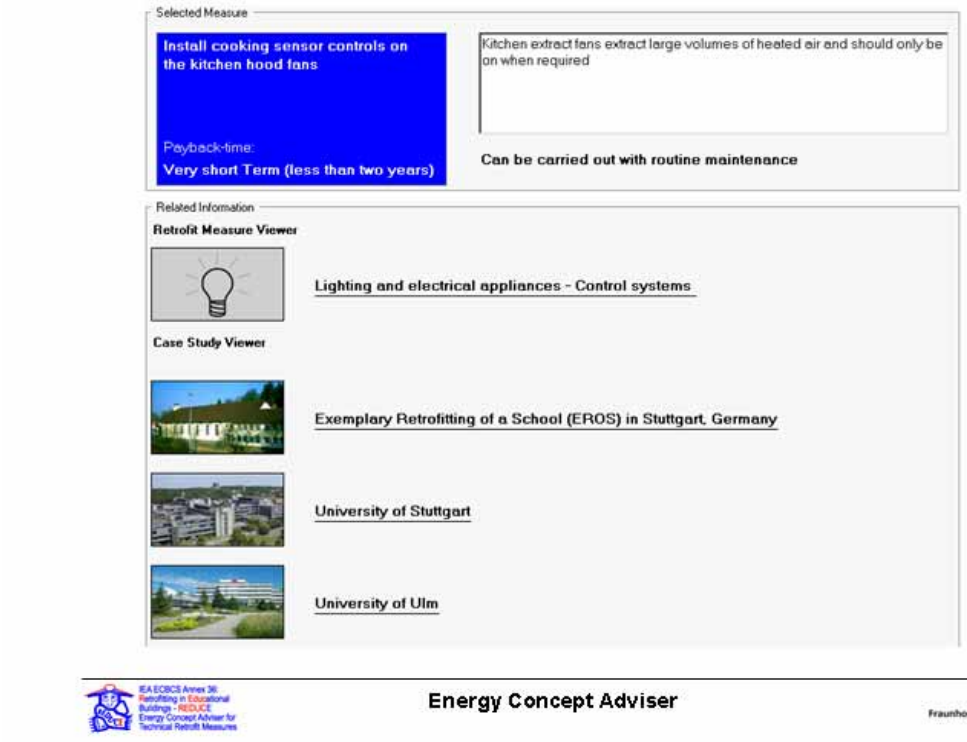

ECA - Structure
Recommendations
Solutions for existing problems
e.g. IAQ, glare, high energy consumption
Case Study Viewer
Collection of exemplary retrofittings of educational buildings sorted by country and building type
Retrofit Measure Viewer
Collection and description of retrofit measures
Benchmarking
Comparisop of the consumption of the own building with the typical average consumption of the country
Retrofit Concept Development
Starting with a building type you are able to analyze different retrofit measures on your own building. You can create different concepts and look on the energy relevant results as well as on the economic calculattions
Auditing & Monitoring
Kulu and Auditing report
Energy Concept Adviser

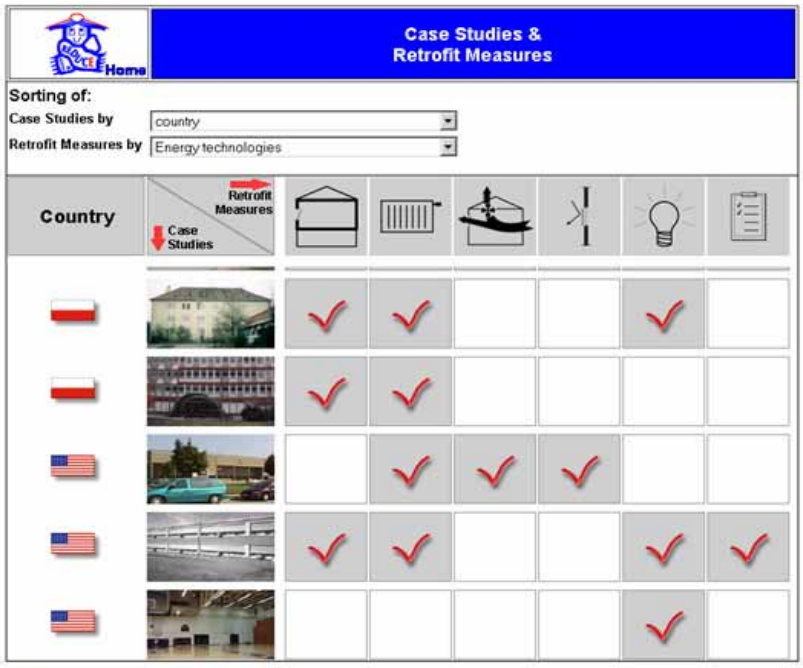

REDUCE
Retrofitting in Educational Buildings
What is the Energy Concept Adviser?
The Energy Concept Adviser (ECA) is an electronic tool assisting in the design of renovations/retrofits focusing on energy savings of educational buildings (schools, university buildings and nursery schools). It will provide a potential list of solutions to specific energy related problems associated with the building shell, lighting or HVAC systems. The ECA contains more that 30 descriptions of exemplary retrofit/renovation projects and provides a wide and varied selection of retrofit technologies and strategies. The ECA will energy rate an existing educational building versus the national average for varied energy sources. Additionally, a calculation tool will provide energy savings and costs for retrofit technologies/strategies selected to be considered for improving the energy efficiency of the educational building.
Who is the target group of the Energy Concept Adviser?
The ECA was developed for educational building decision-makers and their staff, responsible for programming, planning and accomplishing the retrofit/renovation of existing facilities. With the use of the ECA, the energy saving potential within an existing building will be better understood during the development of a retrofit/renovation projects and therefore reduce the energy consumption of an existing building. The decision-makers will be provided with reliable information on conventional and innovative strategies and technologies and thereby gain improved planning reliability.
Who has developed the Energy Concept Adviser?
The Adviser was developed in the framework of the International Energy Agency (IEA) in the project Annex 36 of the Energy Conservation in Buildings and Community Systems division. Experts from 9 European countries and the USA brought in their national expertise, case studies and retrofit technologies to promote energy savings in the retrofit/renovation of existing buildings.
See also Info & Contact .
How to operate the Energy Concept Adviser?
The user-interface is developed for intuitive use; the information paths shall be recognized intuitively. Additional information in the retrofit concept development part is provided under i ; ? is for help functions. The main navigation bars are reached by clicking on the project logo on the upper left side of each page.
Start
Energy Concept Adviser
Fraunhofer Institut Bauphysik

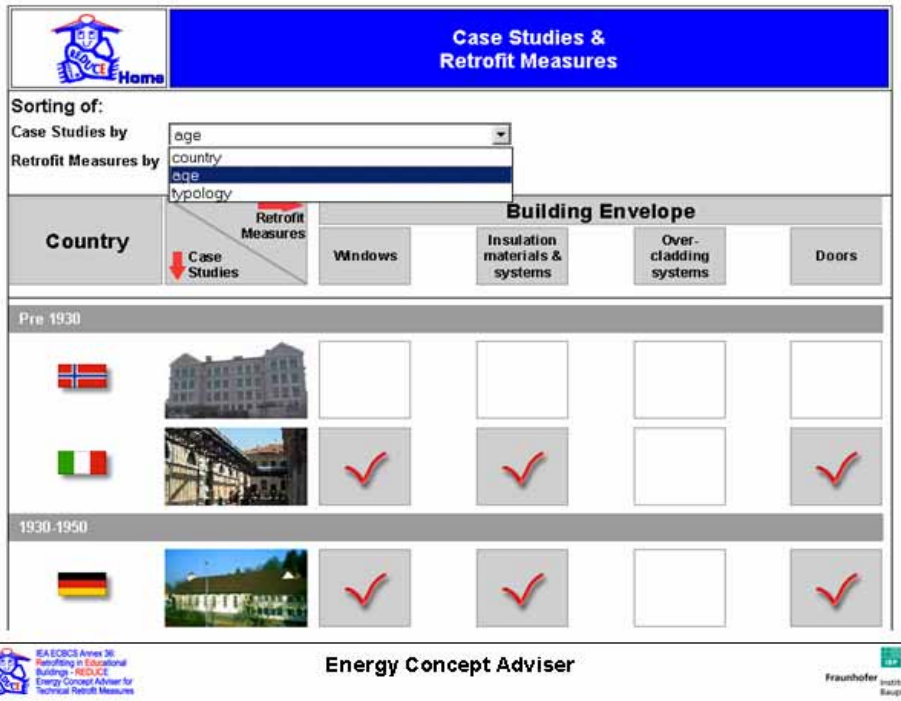

REDUCE
Retrofitting in Educational Buildings
ENERGY CONCEPT ADVISER
for Technical Retrofit Measures
obtain recommendations for specific problems in your building
Recommendations
study more than 30 retrofitted buildings and retrofit measures
Case Studies & Retrofit Measures
compare your building's consumption to national data
Performance Rating
develop an energy efficient retrofit concept for your building
Retrofit Concept
programs and methods to analyse your building performance
Utilities
any questions
Info & Contact
Energy Concept Adviser
Fraunhofer Institut Bauphysik


Home
Problem Related Recommendation
General Information
This knowledge based list of recommended measures may fit only partly to your building.
Select your problem in the left column and in the right column it is possible to group the measures in main groups. Select the useful measures manually and read detailed description in the lower part.
Select the existing problem
General Problems
Heating energy consumption is high
Electrical energy consumption is high
Water consumption is high
Indoor air quality problems
Specific Problems
Building envelope not airtight
Humidity or moisture problems
Windows need replacement
Roof covering needs replacing
Heating controls need upgrading
Pipework needs replacing
Boiler or burner needs replacement
Building fabric insulation is poor
Pipework needs insulating
Ventilation uncomfortable due to draughts
Group measures by
No grouping
Possible measures
Close off open chimneys to prevent ventilation losses an...
Payback time: Very short Term (less than two years)
Close off unused air grilles behind radiators.
Payback time: Very short Term (less than two years)
Weather strip windows and doors and seal gaps in buildi...
Payback time: Very short Term (less than two years)
Install manual swimming pool cover.
Payback time: Very short Term (less than two years)
Replace existing gas or oil-fired boilers with condensing...
Energy Concept Adviser
Fraunhofer Institut Bauphysik


Select the existing problem
General Problems
Heating energy consumption is high
Electrical energy consumption is high
Water consumption is high
Indoor air quality problems
Specific Problems
Building envelope not airtight
Humidity or moisture problems
Windows need replacement
Roof covering needs replacing
Heating controls need upgrading
Pipework needs replacing
Boiler or burner needs replacement
Building fabric insulation is poor
Pipework needs insulating
Ventilation uncomfortable due to draughts
Group measures by
Building envelope
No grouping
Building envelope
Heating systems
Ventilation systems
Lighting and electrical appliances
Management
Payback time: Very short Term (less than two years)
Close off unused air grilles behind radiators.
Payback time: Very short Term (less than two years)
Weather strip windows and doors and seal gaps in buildi...
Payback time: Very short Term (less than two years)
Management of blinds and curtains
Payback time: Very short Term (less than two years)
Fit closures to external doors.
Selected Measure
Weather strip windows and doors and seal gaps in building envelope.
Payback-time:
Very short Term (less than two years)
Weather-strip and caulk around windows, doors, conduits, piping, exterior joints, or other areas of infiltration where it is worn, broken or missing.
Can be carried out with routine maintenance
Energy Concept Adviser
Fraunhofer Institut Bauphysik


Selected Measure
Install cooking sensor controls on the kitchen hood fans
Payback-time:
Very short Term (less than two years)
Kitchen extract fans extract large volumes of heated air and should only be on when required
Can be carried out with routine maintenance
Related Information
Retrofit Measure Viewer
Lighting and electrical appliances - Control systems
Case Study Viewer
Exemplary Retrofitting of a School (EROS) in Stuttgart, Germany
University of Stuttgart
University of Ulm
Energy Concept Adviser


Home
Case Studies & Retrofit Measures
Sorting of:
Case Studies by
country
Retrofit Measures by
Energy technologies
Country
Retrofit Measures
Case Studies
Energy Concept Adviser


Home
Case Studies &
Retrofit Measures
Sorting of:
Case Studies by
age
Retrofit Measures by
country
age
typology
Country
Retrofit Measures
Case Studies
Building Envelope
Windows
Insulation materials & systems
Over-cladding systems
Doors
Pre 1930
1930-1950
Energy Concept Adviser


Home
Case Study Viewer
Revnovation of Wausau West High School - Wausau, Wisconsin, United States
Download of REPORT as PDF
General Data
Site, Typology
Before Retrofit
Retrofit Concept
Energy Savings
User Evaluation
Renovation Costs
Lessons Learned
Additional Information
General Data
Address of project
Wausau West High School, 1200 West Wausau Ave, Wausau, Wisconsin 54401, United States of America
Year of construction
1968
Year of renovation
1998-2001
Total floor area
25548 m²
Number of pupils
1850
Numer of classrooms
65
Typical classroom
65 m²
25 pupils
Wausau West High School
Project Summary
This school building HVAC System resulted in complaints regarding Indoor Air Quality and energy inefficiency. The Local Public Health Department had received complaints and had investigated. The complaints included hot and cold rooms, poor ventilation and poor IAQ. In addition, the lighting systems needed upgrading. The project objective was to improve the IAQ, comfort, and overall energy efficiency of the building.
Retrofit features
The heating system was converted from steam to hot water boilers. Three 9 million BTU boilers were replaced with seven 2 million BTU hot water boilers. The domestic hot water was changed from steam to direct fired natural gas. The dishwasher hot water booster was changed from electricity to gas. Ten pieces of kitchen equipment were changed from electricity to natural gas. Green house changed from propane to natural gas. Lighting was upgraded from T-12 fluorscents with magnetic ballasts to T-8 with electronic ballasts. The HVAC was upgraded using a new concept using existing technologies resulting in 100% outdoor fresh air being introduced into the classrooms.
Energy Concept Adviser

Home | Retrofit Measure Viewer | Solar control and cooling systems | Download of REPORT as PDF

- Introduction
- Shading & glare prot.
- Cooling systems
- Air-conditioning
- Control systems

Shading systems and glare protections

To choose a solar control device we need to consider: the site latitude, the orientation of the facade, the orientation of the openings,the aesthetic of the facade, the glazing type of the window, the need for daylight, the solar control devices.
The overall thermal and optical performance of a solar control device in respect to solar radiation impinging on it is based on the phenomena: primary transmission, reflected transmission, diffuse transmission, solar absorption.
The global shading efficiency of a device is the result of all these direct and indirect transmission processes.

Shading systems and glare protections

Shading devices are also essential to avoid glare situations. If their luminous transmittance is too high, the risk of glare is significant. Several types of shading devices are sufficient to avoid glare from the sky: screens, reflective film, ionised film, sealed blinds.
Designers and decision makers must be conscious that the performance of the shading assembly might be different in the actual application conditions

IEA ECBCS Annex 36: Retrofitting in Educational Buildings - REDUCE Energy Concept Adviser for Technical Retrofit Measures

Energy Concept Adviser

Fraunhofer Institut Bauphysik

Home | Performance Rating

Building Information

The building is a: educational building(general)

It has a heated floor area of: 5000,00

Reference climate zone: mean climate

Click here to get further Information about the climate zones

Consumption of electrical energy:

☐ Includes heat energy consumption

Unit of the consumption: kWh/m²a

Consumption: 56,00

Consumption of heat energy:

Energy source: oil

Unit of the consumption: kWh/m²a

Consumption: 233,00

Consumption of water:

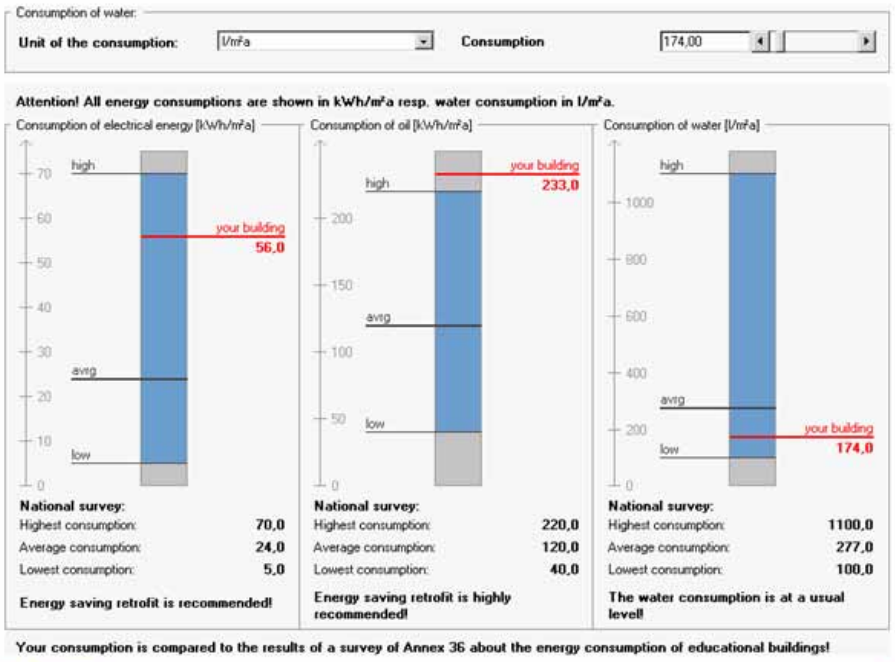
Unit of the consumption: l/m²a

Consumption 174,00

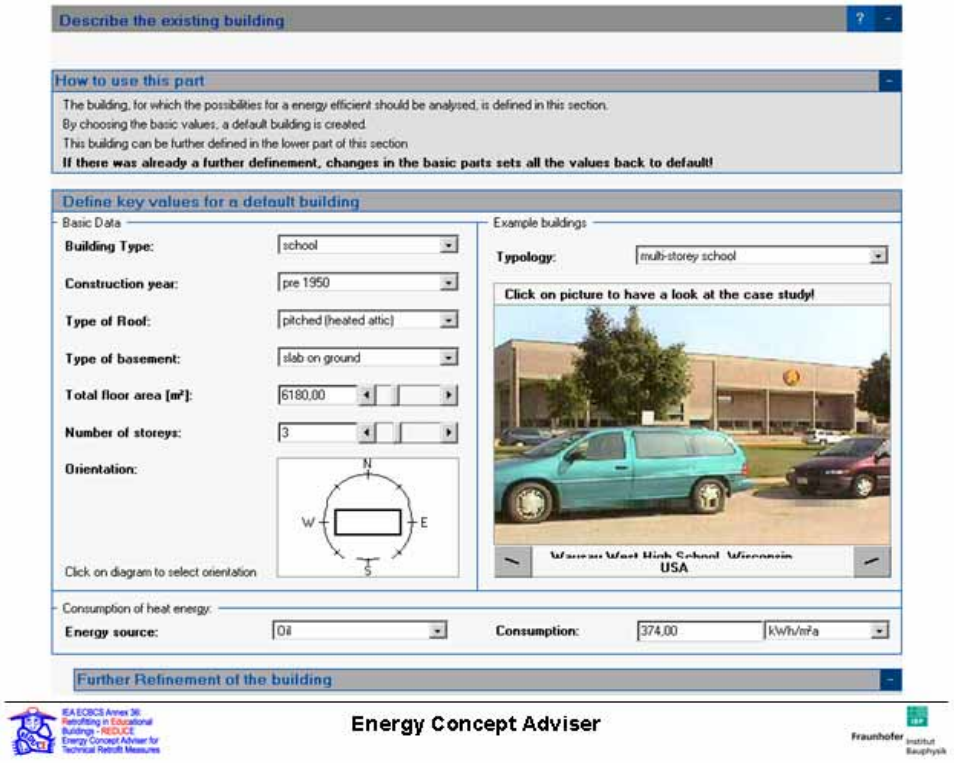
IEA ECBCS Annex 36: Retrofitting in Educational Buildings - REDUCE Energy Concept Adviser for Technical Retrofit Measures

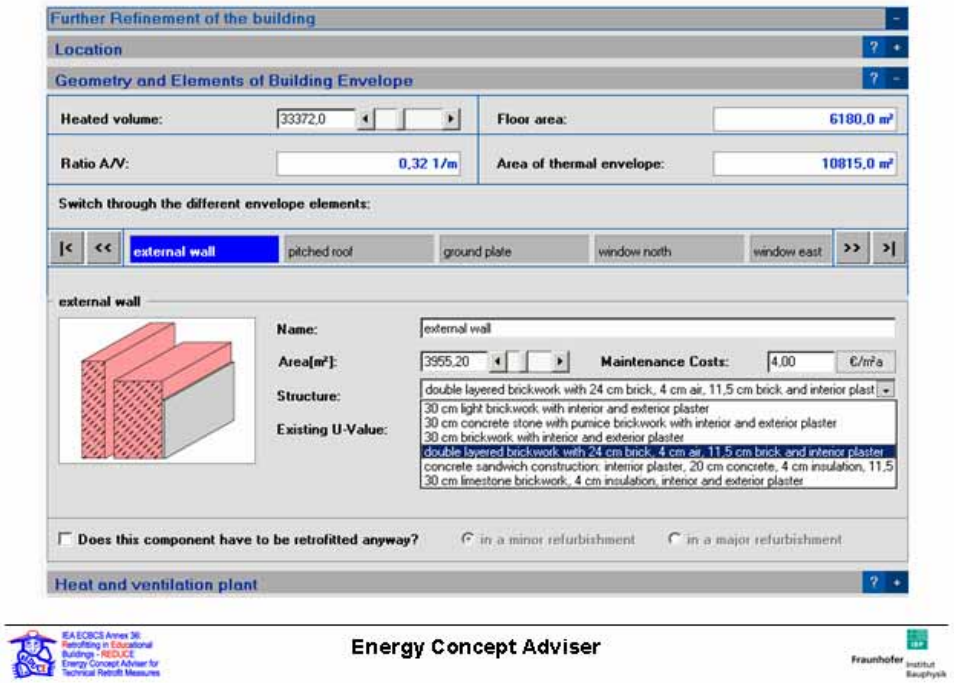
Energy Concept Adviser

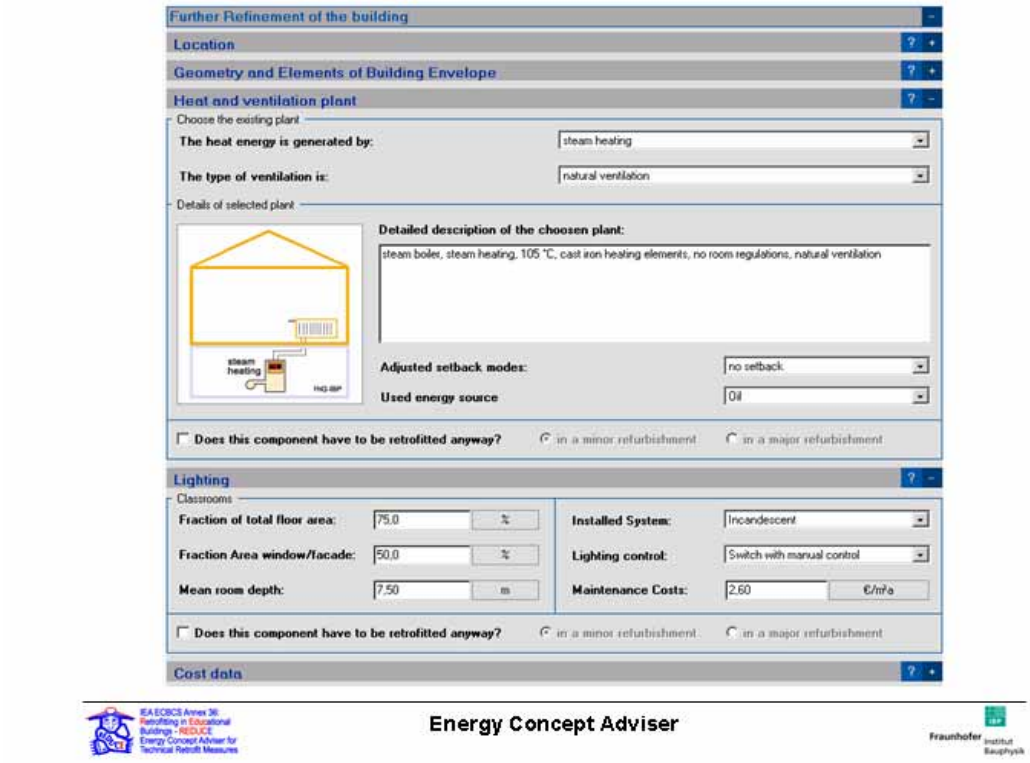
Fraunhofer Institut Bauphysik

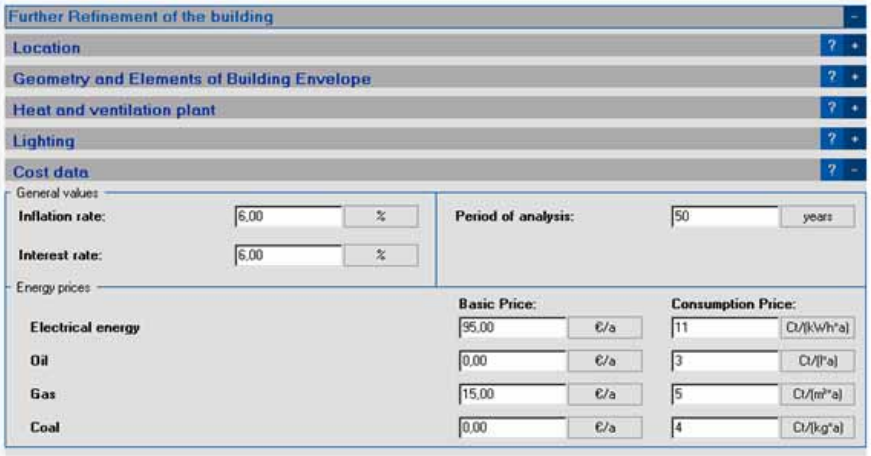

Consumption of water:
Unit of the consumption: l/m²a
Consumption 174,00
Attention! All energy consumptions are shown in kWh/m²a resp. water consumption in l/m²a.
Consumption of electrical energy [kWh/m²a]
high
your building
56,0
avrg
low
National survey:
Highest consumption: 70,0
Average consumption: 24,0
Lowest consumption: 5,0
Energy saving retrofit is recommended!
Consumption of oil [kWh/m²a]
your building
233,0
high
avrg
low
National survey:
Highest consumption: 220,0
Average consumption: 120,0
Lowest consumption: 40,0
Energy saving retrofit is highly recommended!
Consumption of water [l/m²a]
high
avrg
your building
174,0
low
National survey:
Highest consumption: 1100,0
Average consumption: 277,0
Lowest consumption: 100,0
The water consumption is at a usual level!
Your consumption is compared to the results of a survey of Annex 36 about the energy consumption of educational buildings!
Energy Concept Adviser

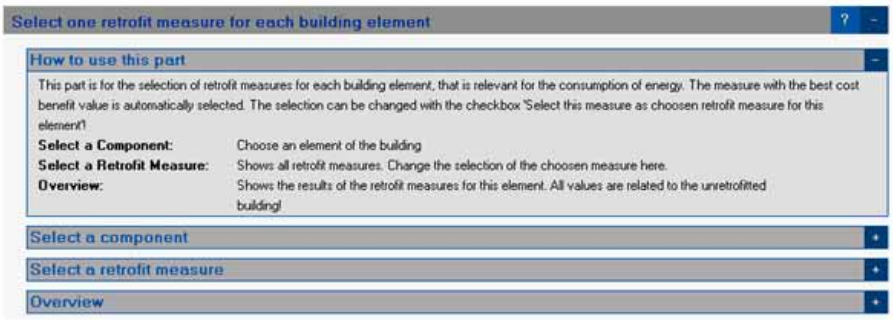

Home
Retrofit Concept Development
General Information
The developement part is structured in the below listed sectors. A sector can be opened or closed by clicking on its bar. For all needed informations (values, costs, etc..) defined values from national studies are deposited, but could be changed individually by the user, so please check the deposited values for your confidence. If you need help, click on ?, for background information click on i
Describe the existing building
Select one retrofit measure for each building element
Create and compare energy saving concept
Summary and Report
Energy Concept Adviser


Describe the existing building
How to use this part
The building, for which the possibilities for a energy efficient should be analysed, is defined in this section.
By choosing the basic values, a default building is created.
This building can be further defined in the lower part of this section
If there was already a further definement, changes in the basic parts sets all the values back to default!
Define key values for a default building
Basic Data
Building Type: school
Construction year: pre 1950
Type of Roof: pitched (heated attic)
Type of basement: slab on ground
Total floor area [m²]: 6180,00
Number of storeys: 3
Orientation:
N
W
E
S
Click on diagram to select orientation
Example buildings
Typology: multi-storey school
Click on picture to have a look at the case study!
USA
Consumption of heat energy:
Energy source: Oil
Consumption: 374,00 kWh/m²a
Further Refinement of the building
Energy Concept Adviser

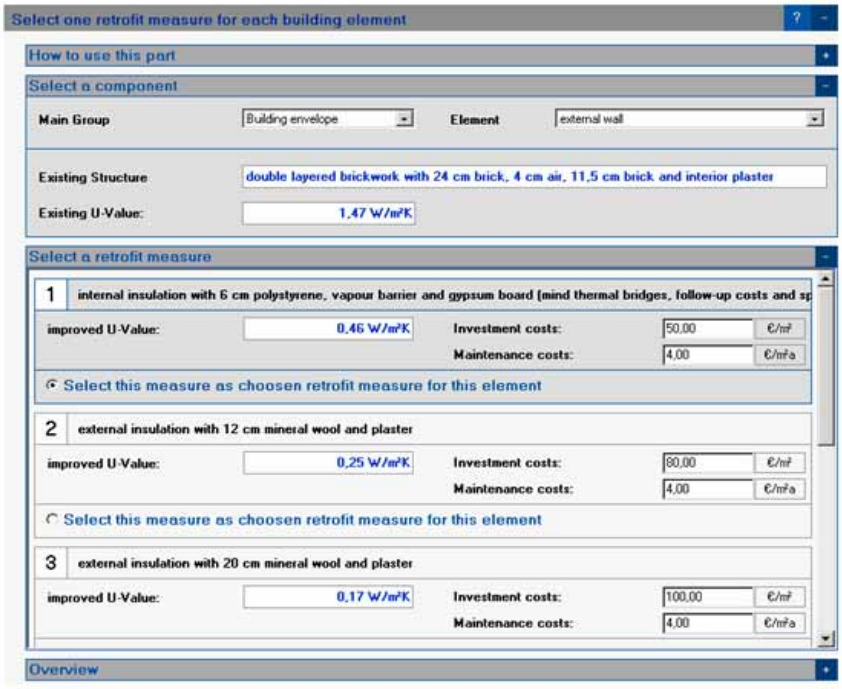

Further Refinement of the building
Location
Geometry and Elements of Building Envelope
Heated volume: 33372,0
Floor area: 6180,0 m²
Ratio A/V: 0,32 1/m
Area of thermal envelope: 10815,0 m²
Switch through the different envelope elements:
external wall
pitched roof
ground plate
window north
window east
external wall
Name: external wall
Area[m²]: 3955,20
Maintenance Costs: 4,00 €/m²a
Structure: double layered brickwork with 24 cm brick, 4 cm air, 11,5 cm brick and interior plast
Existing U-Value:
30 cm light brickwork with interior and exterior plaster
30 cm concrete stone with pumice brickwork with interior and exterior plaster
30 cm brickwork with interior and exterior plaster
double layered brickwork with 24 cm brick, 4 cm air, 11,5 cm brick and interior plaster
concrete sandwich construction: interior plaster, 20 cm concrete, 4 cm insulation, 11,5
30 cm limestone brickwork, 4 cm insulation, interior and exterior plaster
Does this component have to be retrofitted anyway?
in a minor refurbishment
in a major refurbishment
Heat and ventilation plant
Energy Concept Adviser


Further Refinement of the building
Location
Geometry and Elements of Building Envelope
Heat and ventilation plant
Choose the existing plant
The heat energy is generated by:
steam heating
The type of ventilation is:
natural ventilation
Details of selected plant
Detailed description of the choosen plant:
steam boiler, steam heating, 105 °C, cast iron heating elements, no room regulations, natural ventilation
steam heating
Adjusted setback modes:
no setback
Used energy source
Oil
Does this component have to be retrofitted anyway?
in a minor refurbishment
in a major refurbishment
Lighting
Classrooms
Fraction of total floor area:
75,0
%
Fraction Area window/facade:
50,0
%
Mean room depth:
7,50
m
Installed System:
Incandescent
Lighting control:
Switch with manual control
Maintenance Costs:
2,60
€/m²a
Does this component have to be retrofitted anyway?
in a minor refurbishment
in a major refurbishment
Cost data
IEA ECBCS Annex 36: Retrofitting in Educational Buildings - REDUCE Energy Concept Adviser for Technical Retrofit Measures
Energy Concept Adviser
Fraunhofer Institut Bauphysik

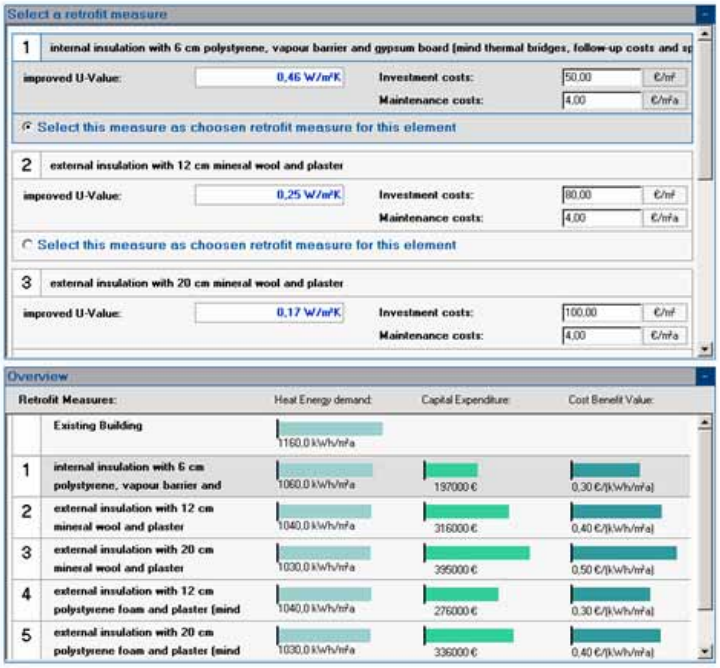

Further Refinement of the building
Location
Geometry and Elements of Building Envelope
Heat and ventilation plant
Lighting
Cost data
General values
Inflation rate:
6,00
%
Interest rate:
6,00
%
Period of analysis:
50
years
Energy prices
Basic Price:
Consumption Price:
Electrical energy
95,00
€/a
11
Ct/[kWh*a]
Oil
0,00
€/a
3
Ct/[l*a]
Gas
15,00
€/a
5
Ct/[m³*a]
Coal
0,00
€/a
4
Ct/[kg*a]


Select one retrofit measure for each building element
How to use this part
This part is for the selection of retrofit measures for each building element, that is relevant for the consumption of energy. The measure with the best cost benefit value is automatically selected. The selection can be changed with the checkbox 'Select this measure as choosen retrofit measure for this element'!
Select a Component: Choose an element of the building
Select a Retrofit Measure: Shows all retrofit measures. Change the selection of the choosen measure here.
Overview: Shows the results of the retrofit measures for this element. All values are related to the unretrofitted building!
Select a component
Select a retrofit measure
Overview

IEA ECBCS Annex 36 Retrofitting in Educational Buildings - REDUCE Energy Concept Adviser for Technical Retrofit Measures
Energy Concept Adviser
Fraunhofer Institut Bauphysik


Select one retrofit measure for each building element
How to use this part
Select a component
Main Group: Building envelope
Element: external wall
Existing Structure: double layered brickwork with 24 cm brick, 4 cm air, 11,5 cm brick and interior plaster
Existing U-Value: 1,47 W/m²K
Select a retrofit measure
1 internal insulation with 6 cm polystyrene, vapour barrier and gypsum board (mind thermal bridges, follow-up costs and sp
improved U-Value: 0,46 W/m²K
Investment costs: 50,00 €/m²
Maintenance costs: 4,00 €/m²a
Select this measure as choosen retrofit measure for this element
2 external insulation with 12 cm mineral wool and plaster
improved U-Value: 0,25 W/m²K
Investment costs: 80,00 €/m²
Maintenance costs: 4,00 €/m²a
Select this measure as choosen retrofit measure for this element
3 external insulation with 20 cm mineral wool and plaster
improved U-Value: 0,17 W/m²K
Investment costs: 100,00 €/m²
Maintenance costs: 4,00 €/m²a
Overview

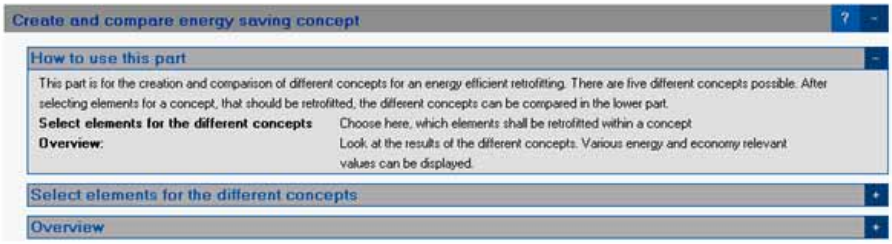
IEA ECBCS Annex 36 Retrofitting in Educational Buildings - REDUCE Energy Concept Adviser for Technical Retrofit Measures
Energy Concept Adviser
Fraunhofer Institut Bauphysik



IEA ECBCS Annex 36 Retrofitting in Educational Buildings - REDUCE Energy Concept Adviser for Technical Retrofit Measures

Energy Concept Adviser

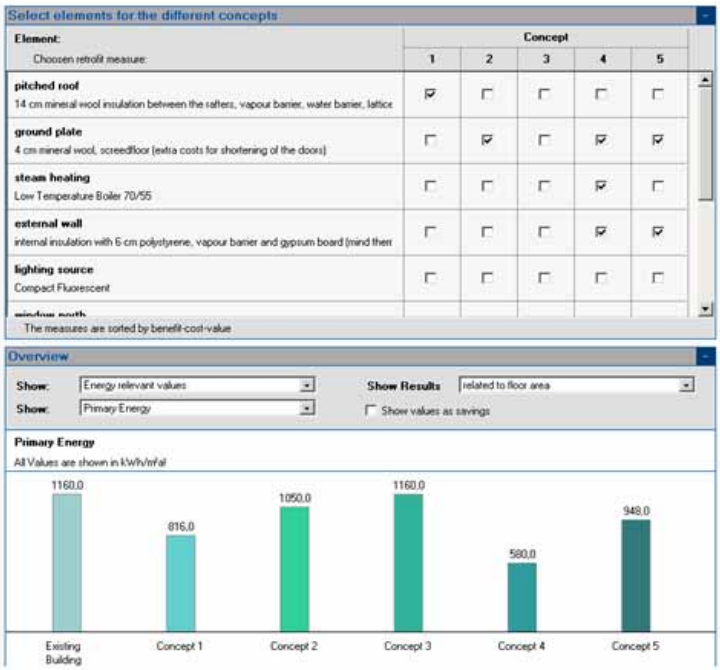
Fraunhofer Institut Bauphysik

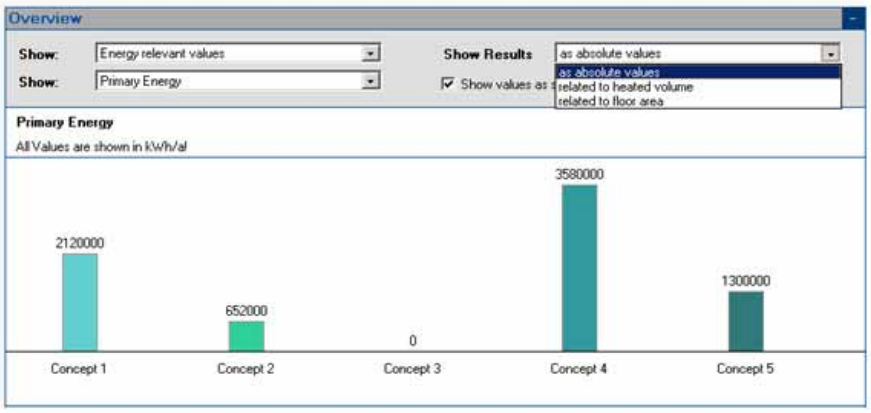


IEA ECBCS Annex 36 Retrofitting in Educational Buildings - REDUCE Energy Concept Adviser for Technical Retrofit Measures

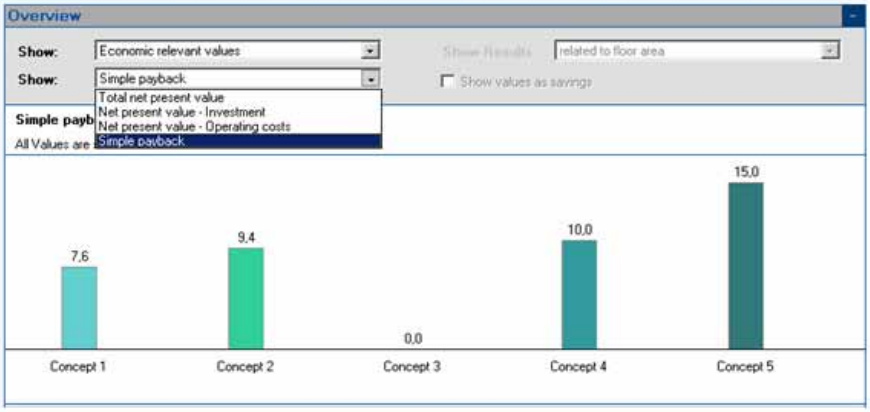
Energy Concept Adviser

Fraunhofer Institut Bauphysik

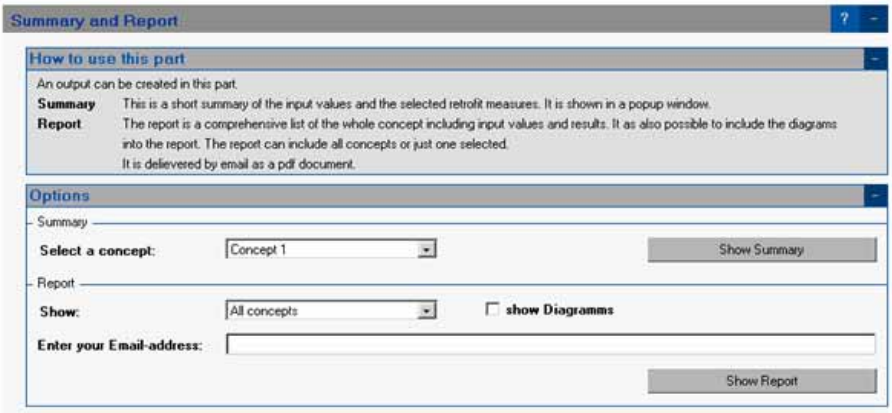

Select elements for the different concepts
Element:
Choosen retrofit measure:
Concept
1
2
3
4
5
pitched roof
14 cm mineral wool insulation between the rafters, vapour barrier, water barrier, lattice
ground plate
4 cm mineral wool, screedfloor (extra costs for shortening of the doors)
steam heating
Low Temperature Boiler 70/55
external wall
internal insulation with 6 cm polystyrene, vapour barrier and gypsum board (mind them
lighting source
Compact Fluorescent
The measures are sorted by benefit-cost-value
Overview
Show:
Energy relevant values
Show:
Primary Energy
Show Results
related to floor area
Show values as savings
Primary Energy
All Values are shown in kWh/m²al
1160,0
816,0
1050,0
1160,0
580,0
948,0
Existing Building
Concept 1
Concept 2
Concept 3
Concept 4
Concept 5

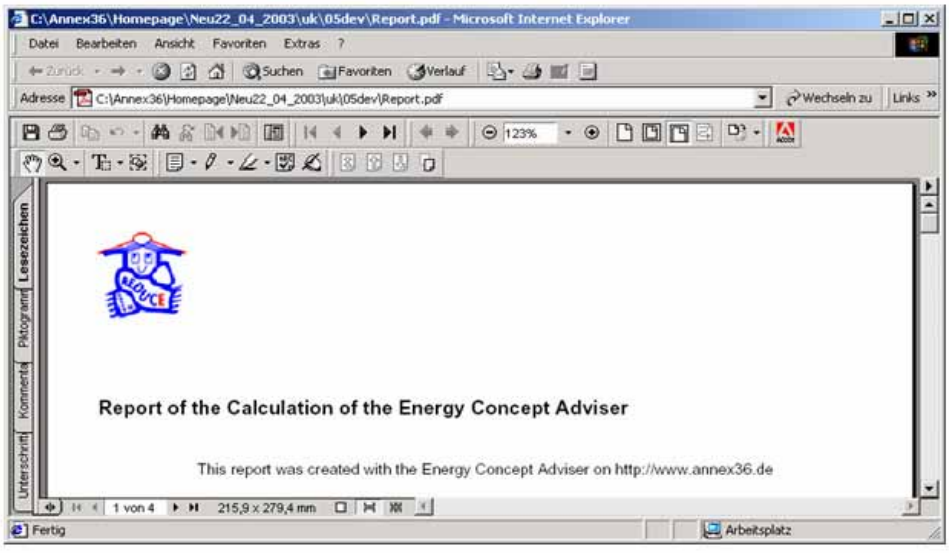

Overview
Show:
Energy relevant values
Show:
Primary Energy
Show Results
as absolute values
as absolute values
related to heated volume
related to floor area
Show values as s
Primary Energy
All Values are shown in kWh/al
2120000
652000
0
3580000
1300000
Concept 1
Concept 2
Concept 3
Concept 4
Concept 5

Energy Concept Adviser



Energy Concept Adviser


Summary and Report
How to use this part
An output can be created in this part.
Summary This is a short summary of the input values and the selected retrofit measures. It is shown in a popup window.
Report The report is a comprehensive list of the whole concept including input values and results. It as also possible to include the diagrams into the report. The report can include all concepts or just one selected.
It is delievered by email as a pdf document.
Options
Summary
Select a concept:
Concept 1
Show Summary
Report
Show:
All concepts
show Diagramms
Enter your Email-address:
Show Report


C:\Annex36\Homepage\Neu22_04_2003\uk\05dev\Report.pdf - Microsoft Internet Explorer
Datei Bearbeiten Ansicht Favoriten Extras ?
Suchen Favoriten Verlauf
Adresse C:\Annex36\Homepage\Neu22_04_2003\uk\05dev\Report.pdf
Wechseln zu Links
123%
Lesezeichen Piktogramm Kommentar Unterschrift
Report of the Calculation of the Energy Concept Adviser
This report was created with the Energy Concept Adviser on http://www.annex36.de
1 von 4 215,9 x 279,4 mm
Fertig
Arbeitsplatz

Home

Utilities

KULU IEA ECBCS Annex 36

VTT

Home

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Information

http://www.annex36.bizland.com/

Energy Design Assistance for High Performance Buildings

Presenter: Mr. David A. Eijadi. The Weidt Group

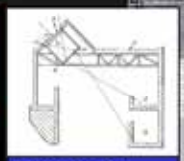
Fundamentals

We are what we repeatedly do.

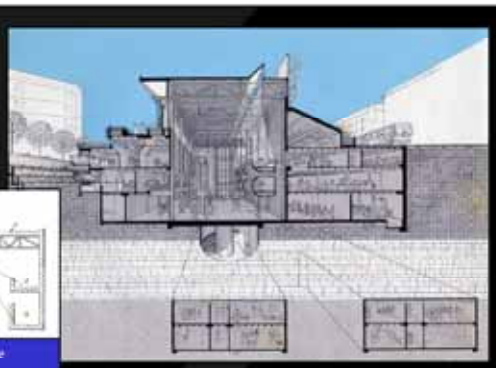
Aristotle

Building Energy Performance Through Advanced Technologies ...

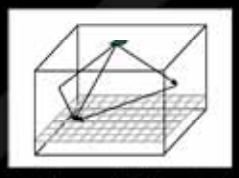
... The Early years

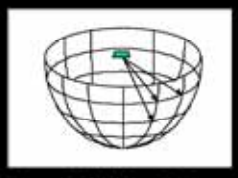


Introduced the concepts of Reflective and Refractive Solar Optics as well as Solar Photometrics.



Civil / Mineral Engineering Building 1978 - 1983
BRW Architects





Architectural Lighting Design vs. Engineering Lighting Design

Building Energy Performance
Through Advanced Technologies …

… The Early years

Evolutionary Development

1978 - 1983
BRW Architects

Peoria Innovations
- Reclaimed Desert from Farmland
- Reduced non permeable areas
- Shaded pedestrian areas
- Water conservation
  - Xeriscape
  - Cooling tower/ Water feature
  - Desert walk
- Energy Efficiency
  - Heat exchanger
  - Articulated skin
  - Reduced office depth
  - Daylighting
- Local materials

Peoria, Arizona

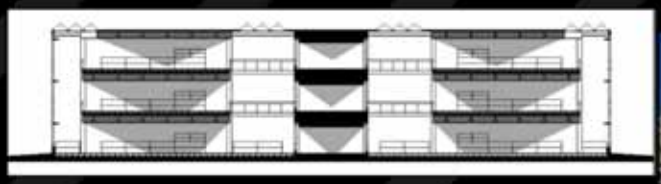
Sedona, Arizona

Building Energy Performance
Through Advanced Technologies …

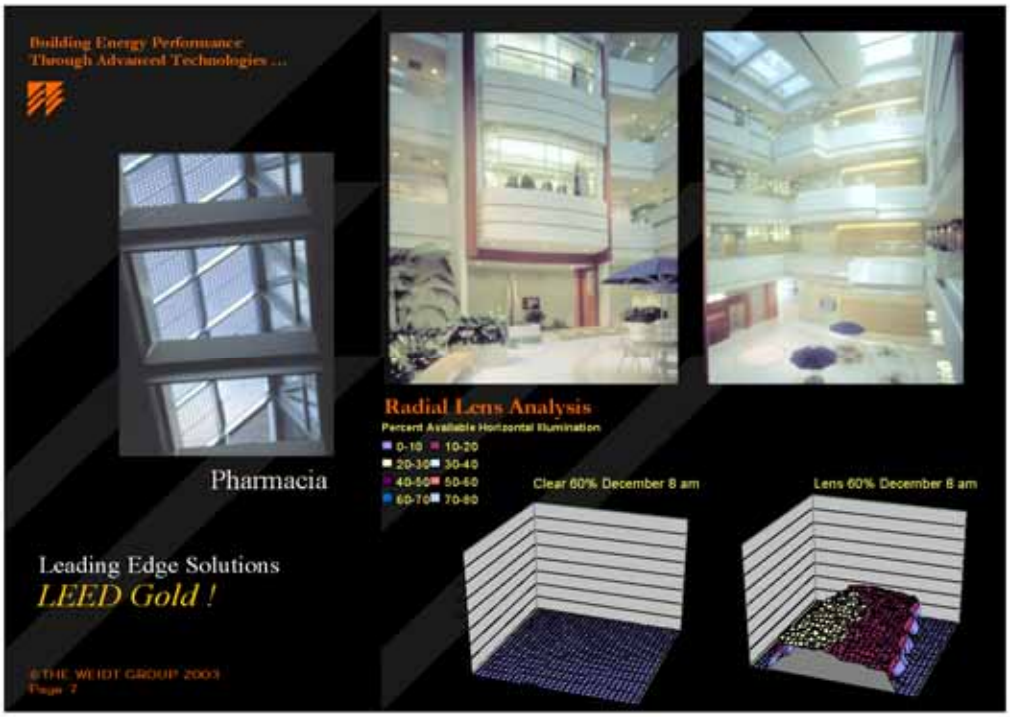
Leading Edge Projects with The Weidt Group

Andersen Skylight Prototype

WalMart EcoMart



ADC Corporate World Headquarters


Building Energy Performance
Through Advanced Technologies ...
Pharmacia
Radial Lens Analysis
Percent Available Horizontal Illumination
0-10 10-20
20-30 30-40
40-50 50-60
60-70 70-80
Clear 60% December 8 am
Lens 60% December 8 am
Leading Edge Solutions
LEED Gold !
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Building Energy Performance
Through Advanced Technologies ...
American Express
ComTal Manufacturing
Conventional
Main Stream
Solutions
25% to 60% Better than Code
Bridgewater Elementary
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Building Energy Performance
Through Advanced Technologies …

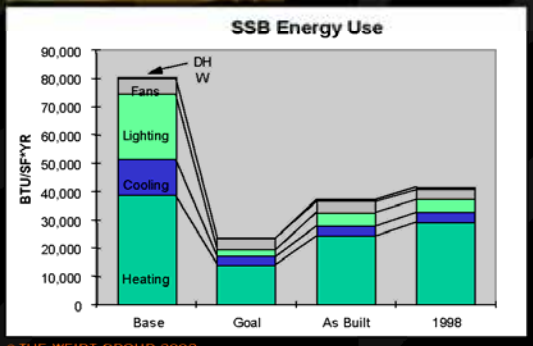
The Weidt Group
A History of Innovation in Measurable Successes

- Founding Members Building Energy Performance Standards (B.E.P.S)
- Founding Members of ASHRAE 90.1 Committee
- Founding Members of the NFRC
- Participants in DOE's Whole Building Design Round Table
- Pioneers in software for the A/E Industry
- Founding Members International Program for Measurement and Verification Protocols (IPMVP) for New Construction
- LEED Certified Consultants
- Contributors to NCARB Sustainable Design monograph

Building Energy Performance
Through Advanced Technologies …

Security State Bank

Very Long Term Verification



- 18 Years Later, Does It Still Work?
- Yes, still performing as built
- Compared to Standard 1980 Practice
  - Fans 60% of base
  - Lighting 20% of base
  - Cooling 30% of base
  - Heating 75% of base


Building Energy Performance
Through Advanced Technologies ...
Recent Recognition
Illumination Design Award 2002
UW-Whitewater Fieldhouse
IESNA
Project of Distinction 2002
Jordan Park Schools
Council of Facility Planners International
Merit Award for New Construction
The Pharmacia Building Q 2001
Presented by Chicago Building Congress
Architecture + Energy Award
Iowa Association of Municipal Utilities 2001
The Program Most Likely to Meet the Intent of the
Kyoto Protocols in the Shortest Time
Presented by European Council for an
Energy Efficient Economy (ECEEE)
Xcel Energy's Energy Assets Program 2001
AIA's Top 10 for Earth Day 2000
Presented by the Committee on the Environment
The Green Institute's Phillips Eco-Enterprise Center and Northland
College Student Housing 2000
Environmental Initiative Award
presented by the Minnesota Environmental Initiative
NSP Energy Assets 2000
Energy Efficiency Design Award of the Year
Presented by MidAmerican Energy
Meredith Publishing Company 1997
ARCHITECTURE
ENERGY+
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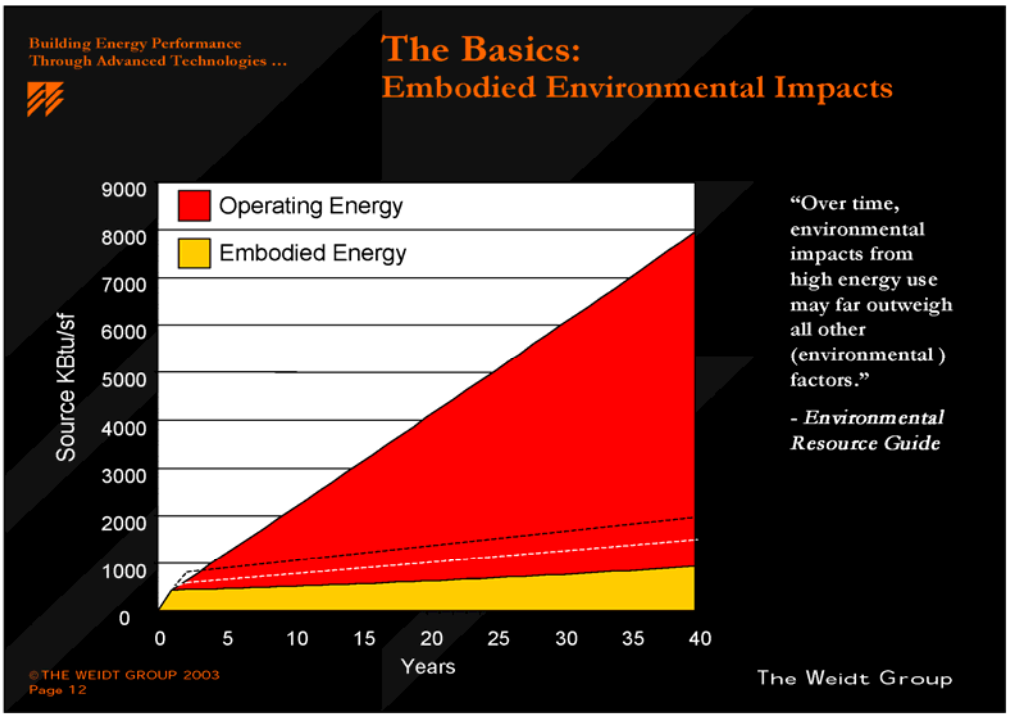
Building Energy Performance
Through Advanced Technologies ...
The Basics:
Embodied Environmental Impacts
Operating Energy
Embodied Energy
Source KBtu/sf
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 5 10 15 20 25 30 35 40
Years
"Over time, environmental impacts from high energy use may far outweigh all other (environmental) factors."
- Environmental Resource Guide
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Building Energy Performance
Through Advanced Technologies ...
Outline
Who we are
Rules and Practice
Failure and Success
Examples
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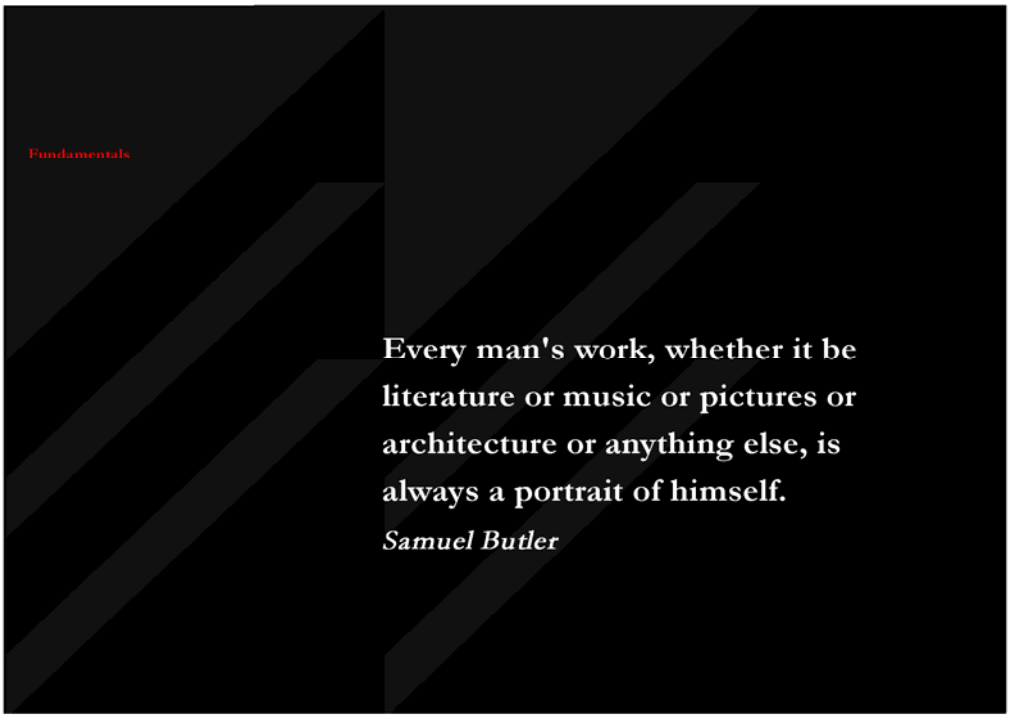
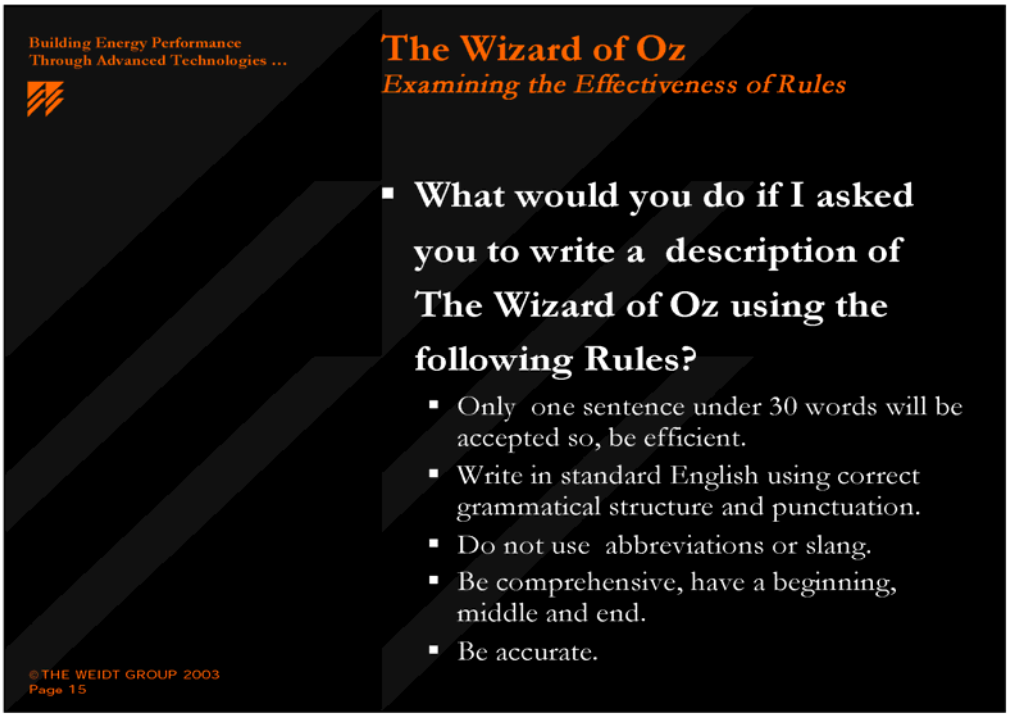

Fundamentals
Every man's work, whether it be literature or music or pictures or architecture or anything else, is always a portrait of himself.
Samuel Butler


Building Energy Performance
Through Advanced Technologies ...
The Wizard of Oz
Examining the Effectiveness of Rules
What would you do if I asked you to write a description of The Wizard of Oz using the following Rules?
Only one sentence under 30 words will be accepted so, be efficient.
Write in standard English using correct grammatical structure and punctuation.
Do not use abbreviations or slang.
Be comprehensive, have a beginning, middle and end.
Be accurate.
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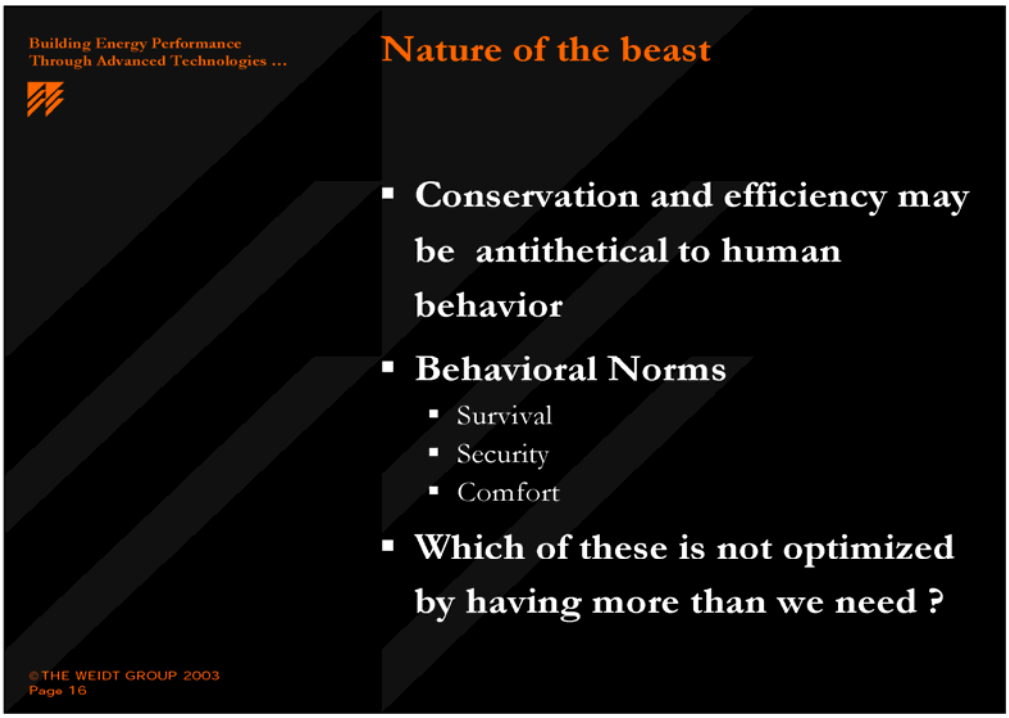
Building Energy Performance
Through Advanced Technologies ...
Nature of the beast
Conservation and efficiency may be antithetical to human behavior
Behavioral Norms
Survival
Security
Comfort
Which of these is not optimized by having more than we need ?
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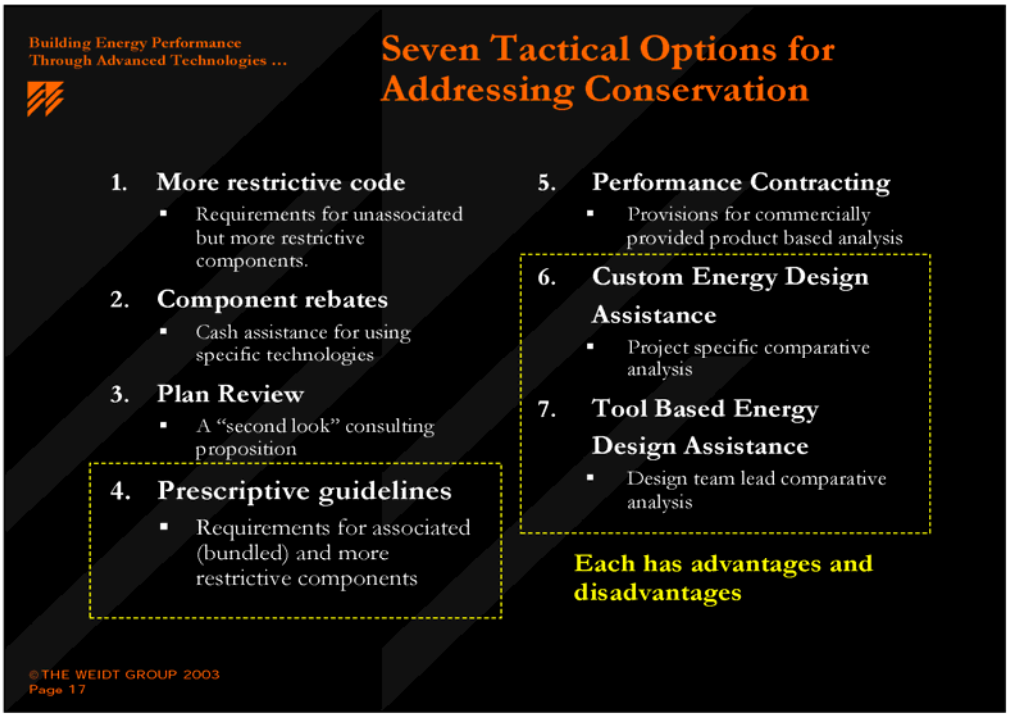
Building Energy Performance
Through Advanced Technologies …
Seven Tactical Options for Addressing Conservation
1. More restrictive code
Requirements for unassociated but more restrictive components.
2. Component rebates
Cash assistance for using specific technologies
3. Plan Review
A "second look" consulting proposition
4. Prescriptive guidelines
Requirements for associated (bundled) and more restrictive components
5. Performance Contracting
Provisions for commercially provided product based analysis
6. Custom Energy Design Assistance
Project specific comparative analysis
7. Tool Based Energy Design Assistance
Design team lead comparative analysis
Each has advantages and disadvantages
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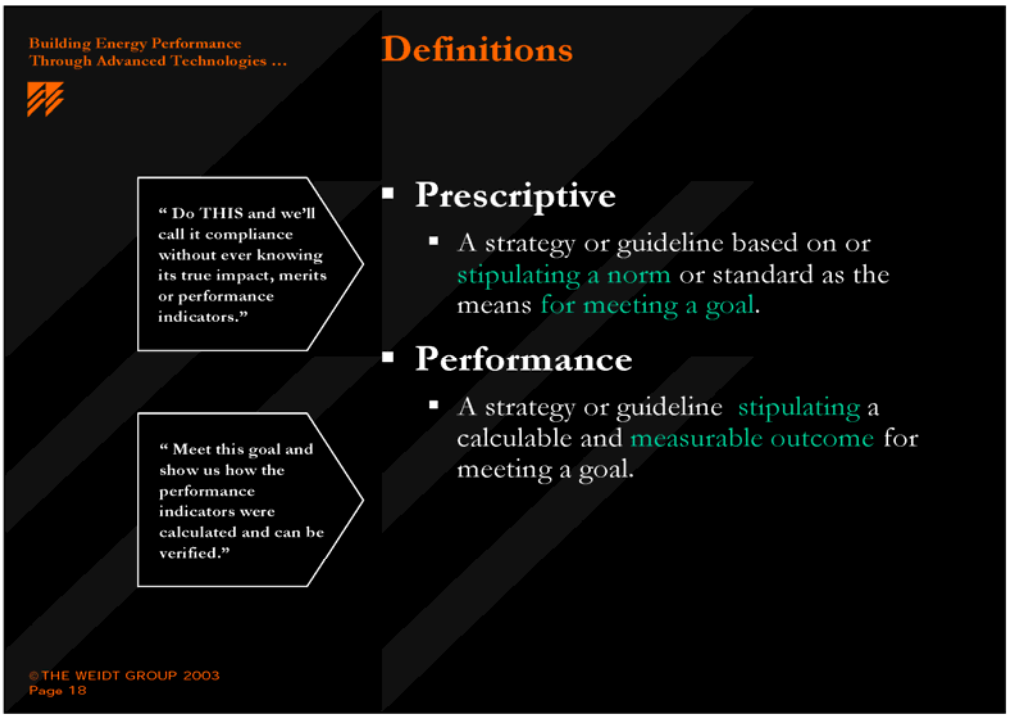
Building Energy Performance
Through Advanced Technologies …
Definitions
" Do THIS and we'll call it compliance without ever knowing its true impact, merits or performance indicators."
Prescriptive
A strategy or guideline based on or stipulating a norm or standard as the means for meeting a goal.
" Meet this goal and show us how the performance indicators were calculated and can be verified."
Performance
A strategy or guideline stipulating a calculable and measurable outcome for meeting a goal.
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Building Energy Performance
Through Advanced Technologies …
Rules and Practice
Change Cycle
• Challenge and Innovation
• Creativity and Development
• Compromise and Codification
• Complacency and Stagnation
Repeat
• Challenge and Innovation
• Creativity and Development
• Compromise and Codification
• Complacency and Stagnation
Repeat
Make Rules
Develop Codes
Develop Guidelines
Develop Enforcement
Certify
Organizational efficiency at an operational cost
Perform Analysis
Improve tools
Improve consulting practices
Improve reporting
Verify
Operational efficiency at an organizational cost
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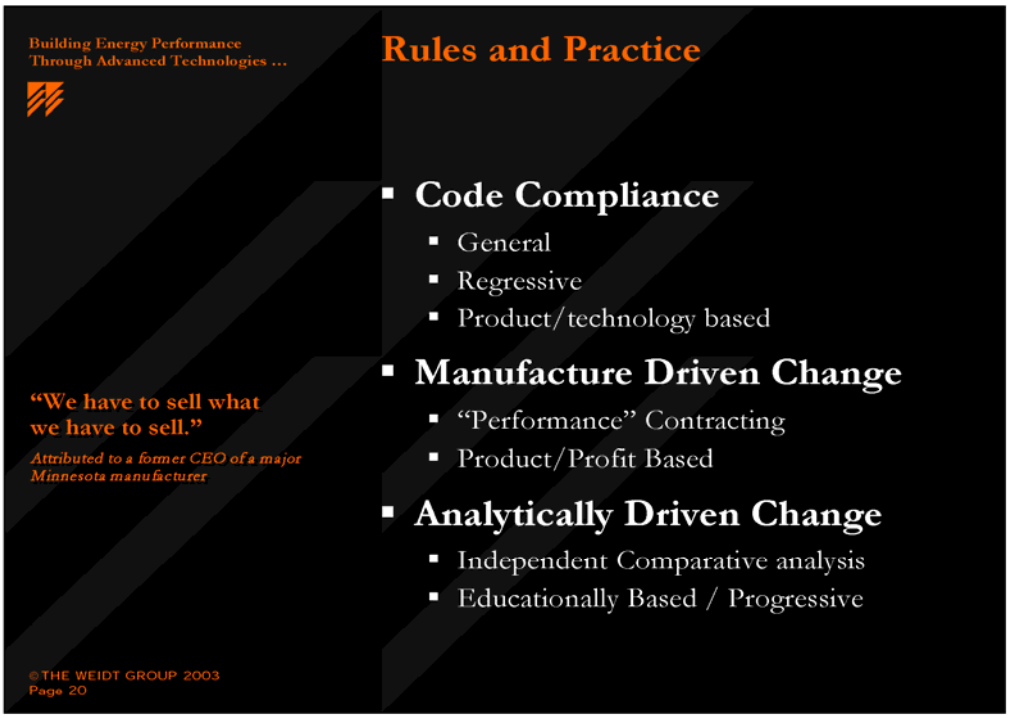
Building Energy Performance
Through Advanced Technologies …
Rules and Practice
"We have to sell what we have to sell."
Attributed to a former CEO of a major Minnesota manufacturer
Code Compliance
General
Regressive
Product/technology based
Manufacture Driven Change
"Performance" Contracting
Product/Profit Based
Analytically Driven Change
Independent Comparative analysis
Educationally Based / Progressive
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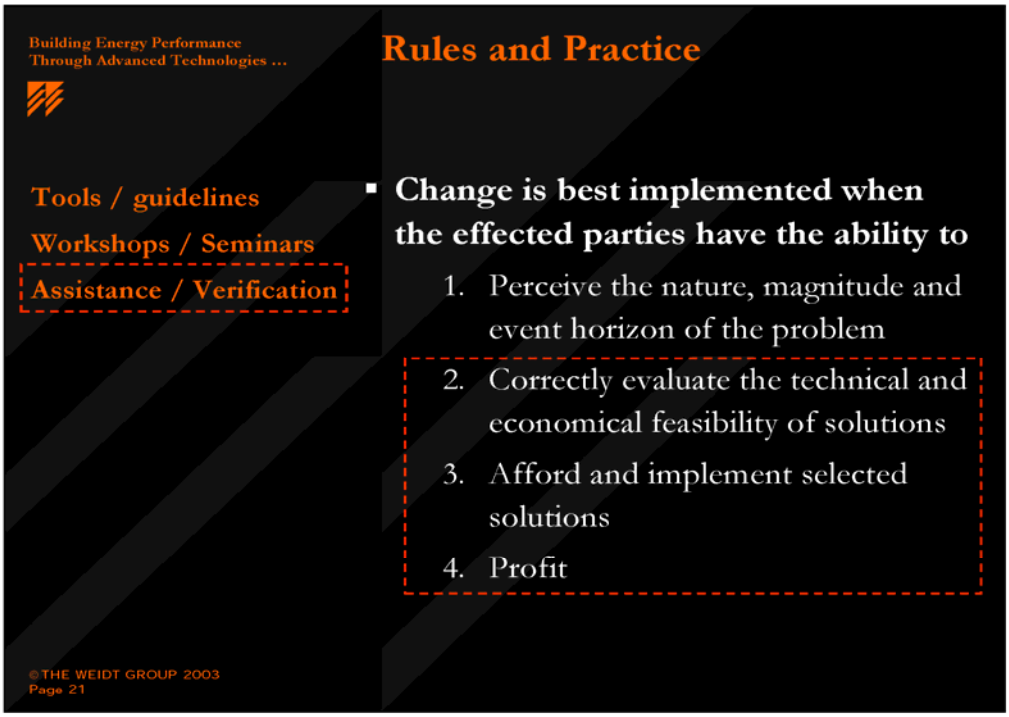
Building Energy Performance
Through Advanced Technologies ...
Rules and Practice
Tools / guidelines
Workshops / Seminars
Assistance / Verification
Change is best implemented when the effected parties have the ability to
1. Perceive the nature, magnitude and event horizon of the problem
2. Correctly evaluate the technical and economical feasibility of solutions
3. Afford and implement selected solutions
4. Profit
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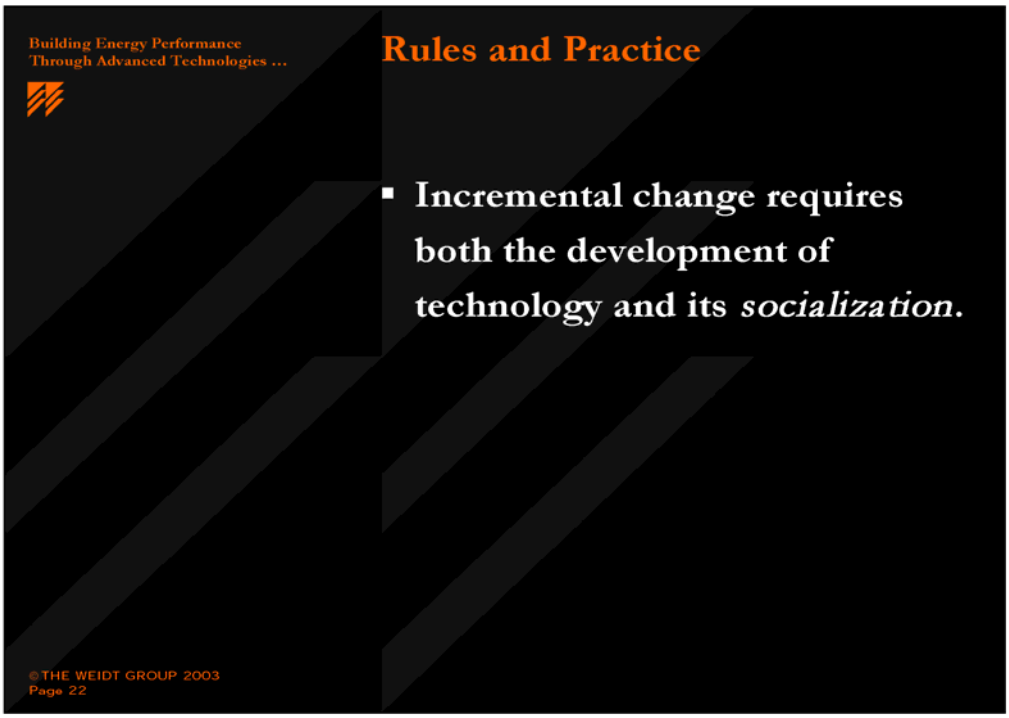
Building Energy Performance
Through Advanced Technologies ...
Rules and Practice
Incremental change requires both the development of technology and its socialization.
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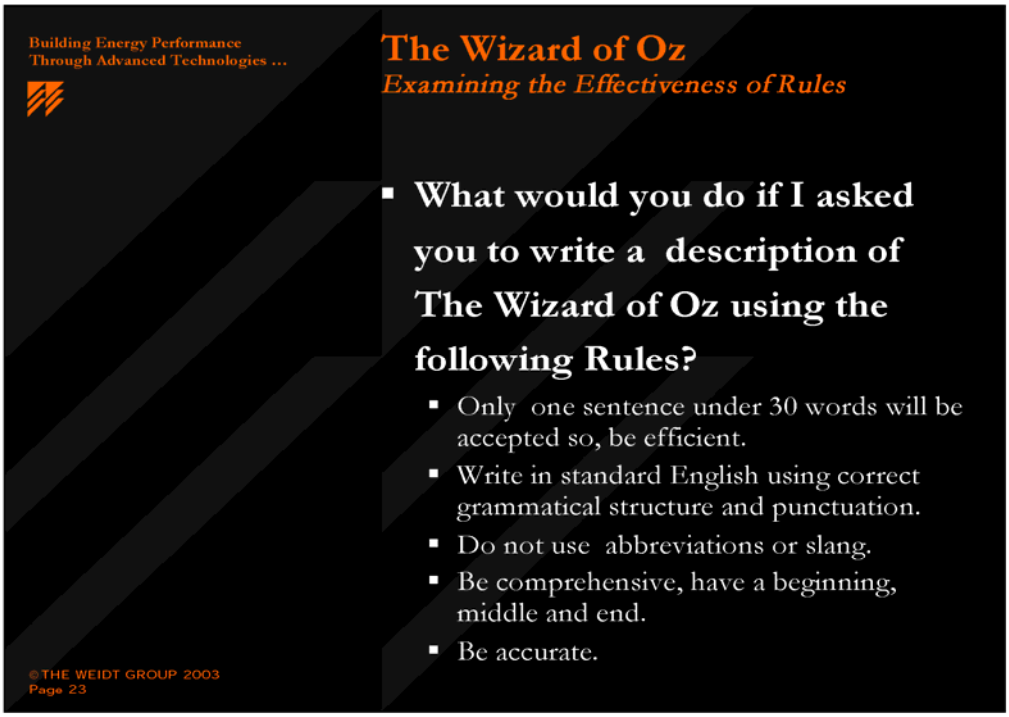
Building Energy Performance
Through Advanced Technologies ...
The Wizard of Oz
Examining the Effectiveness of Rules
What would you do if I asked you to write a description of The Wizard of Oz using the following Rules?
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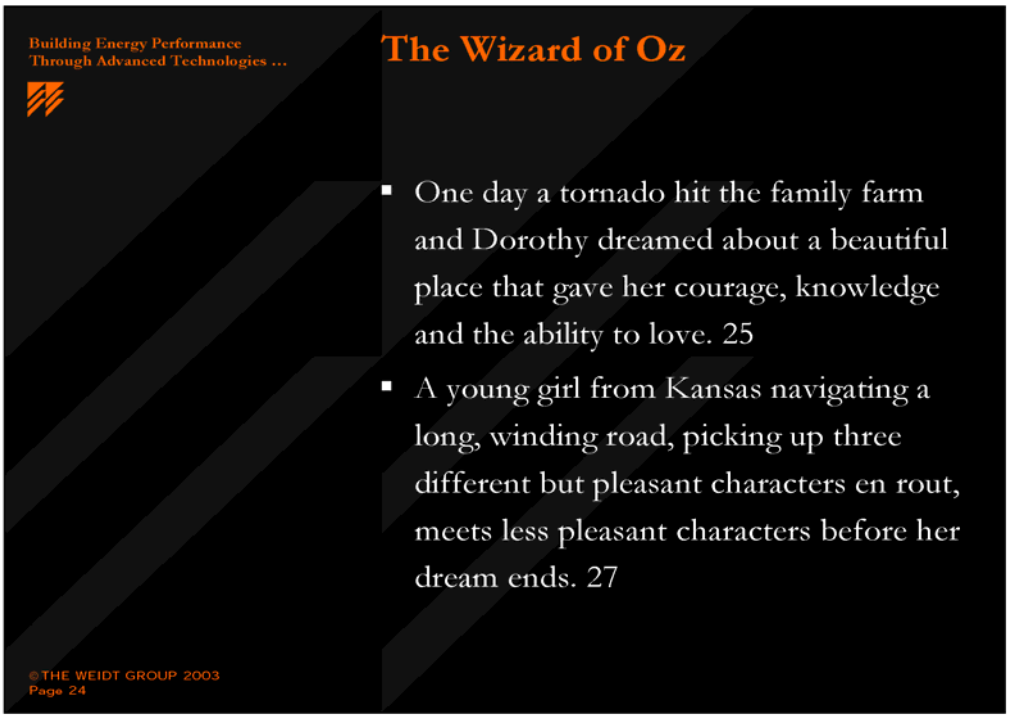
Building Energy Performance
Through Advanced Technologies ...
The Wizard of Oz
One day a tornado hit the family farm and Dorothy dreamed about a beautiful place that gave her courage, knowledge and the ability to love. 25
A young girl from Kansas navigating a long, winding road, picking up three different but pleasant characters en rout, meets less pleasant characters before her dream ends. 27
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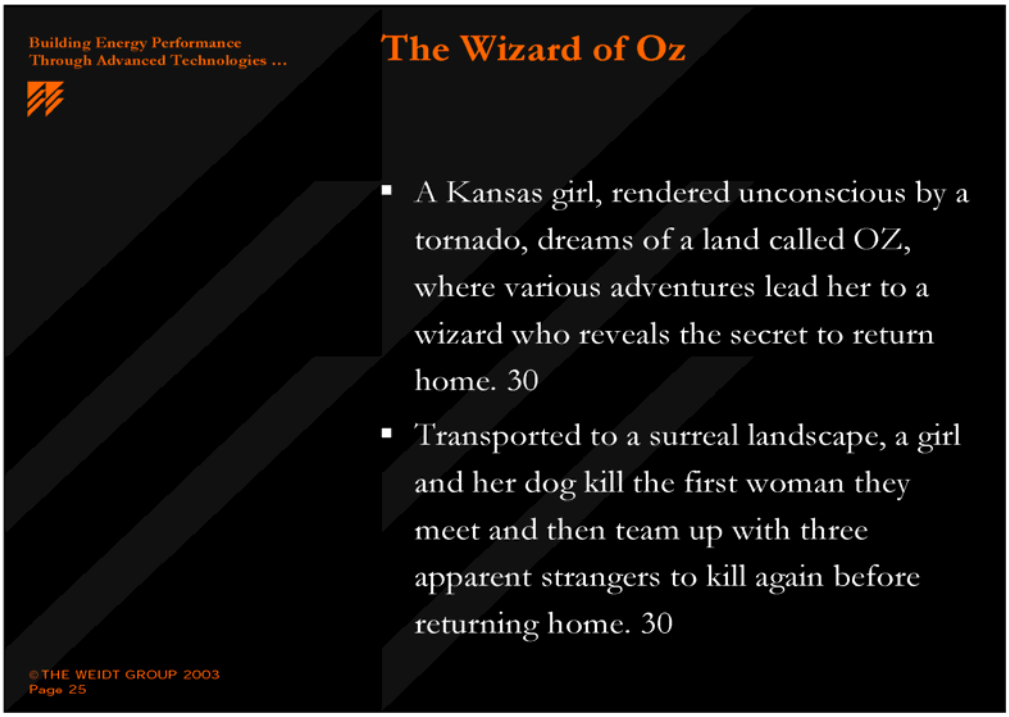
Building Energy Performance
Through Advanced Technologies ...
The Wizard of Oz
A Kansas girl, rendered unconscious by a tornado, dreams of a land called OZ, where various adventures lead her to a wizard who reveals the secret to return home. 30
Transported to a surreal landscape, a girl and her dog kill the first woman they meet and then team up with three apparent strangers to kill again before returning home. 30
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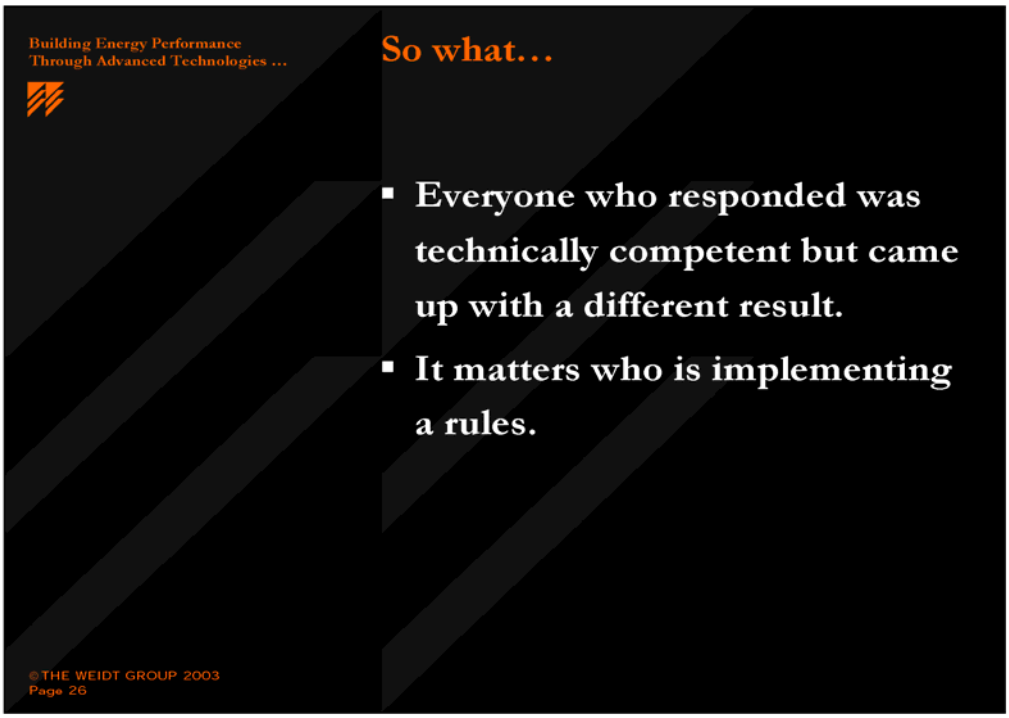
Building Energy Performance
Through Advanced Technologies ...
So what…
Everyone who responded was technically competent but came up with a different result.
It matters who is implementing a rules.
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Building Energy Performance
Through Advanced Technologies ...
Outline
Who we are
Rules and Practice
Failure and Success
Examples
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Fundamental Truths
The only thing harder to change than law is custom.
Will Durant
The History of Western Civilization

Building Energy Performance
Through Advanced Technologies ...

Failure Modes

- **Conceptual Failure**
  - Failed Social Construct
  - Failed Operational Construct
- **Technological Failure**
  - Immature Design
  - Quality Control
- **Design Failure**
  - Unfamiliarity
  - Incomplete Specification
- **Construction / Implementation Failure**
  - Unfamiliarity
  - Incomplete Specification
- **Operational Failure**
  - Failed Social Construct
  - Failed Operational Construct

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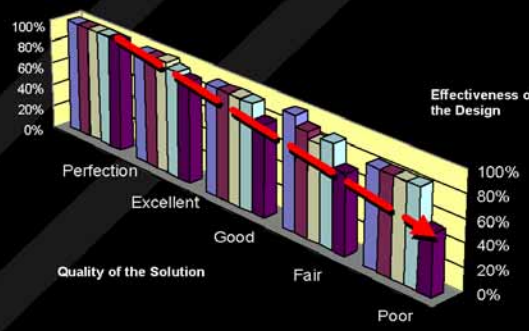
Building Energy Performance
Through Advanced Technologies ...

Rules and Practice
System Efficacy

Component	Perfection	Excellent	Good	Fair	Poor
Window size	100%	98%	95%	100%	85%
Sun shading	100%	98%	95%	91%	85%
Lighting design	100%	99%	95%	85%	85%
Calibration	100%	95%	95%	90%	85%
Total	**100%**	**90%**	**81%**	**70%**	**52%**



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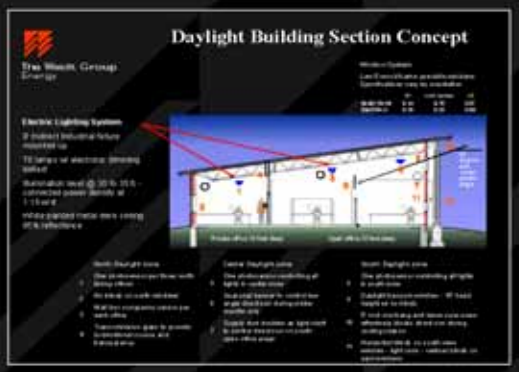
Building Energy Performance Through Advanced Technologies …

Fundamentals of Integrated Daylighting Design



- No *one person* does Daylighting
- It is a collaborative effort of the design team
  - Architect
  - Lighting designer
  - Electrical engineer
  - Interior Designer

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Building Energy Performance Through Advanced Technologies …

Daylighting Component Performance

Daylighting System Performance

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1 Glazing Location	100%	70%	100%	100%
2 Glazing Type	100%	93%	100%	100%
4 Interior Finishes	100%	85%	100%	100%
3 Sun Control	100%	65%	100%	100%
5 Partition Height	100%	70%	100%	100%
6 Lighting Design				
Lamp Type	100%	100%	100%	100%
Fixture Type	100%	100%	100%	100%
Fixture Layout	100%	100%	100%	100%
7 Lighting Control				100%
Circuting of fixtures	100%	100%	50%	100%
Photosensor location	100%	100%	50%	100%
Photo Sensor Calibration	100%	100%	100%	5%
8 HVAC Design	100%	100%	100%	100%
System Performance	100%	25%	25%	5%

Controls the Quantity and Quality of Daylight in the space

Also Controls the Quantity and Quality of Light in the space AND Controls the amount of electric lighting energy which can be saved

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Building Energy Performance
Through Advanced Technologies …

Current State of Practice
Occupant Requirements

GOOD:
Generally Works well, need to consider orientation issues earlier in design

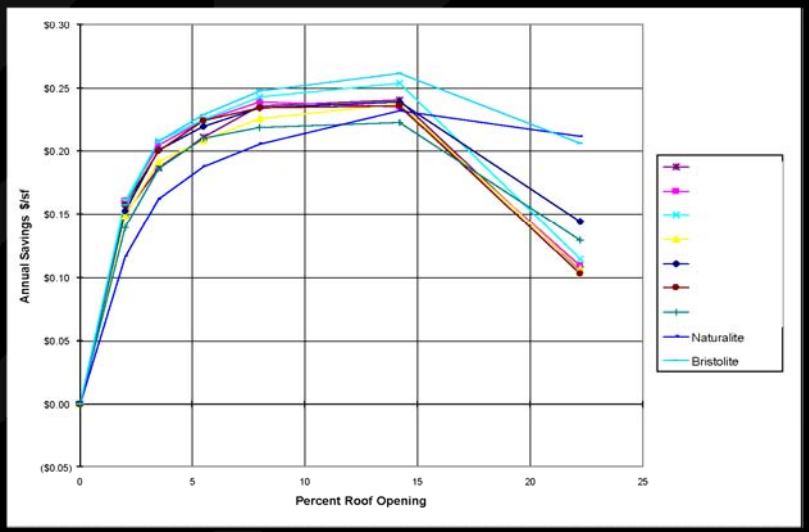
FAIR:
Window blind/ shade selection to consider daylight effectiveness, furnishing color to consider contrast with windows

POOR:
Biggest barrier for current practice

1. Having enough daylight inside a space to make it an effective illumination source, and to have views of the outside.
2. Maintain appropriate interior luminance contrast ratios by modulating the daylight sources to
3. Implementing a lighting control strategy that controls the electric lights dynamically based on daylight to save energy without distracting occupants.

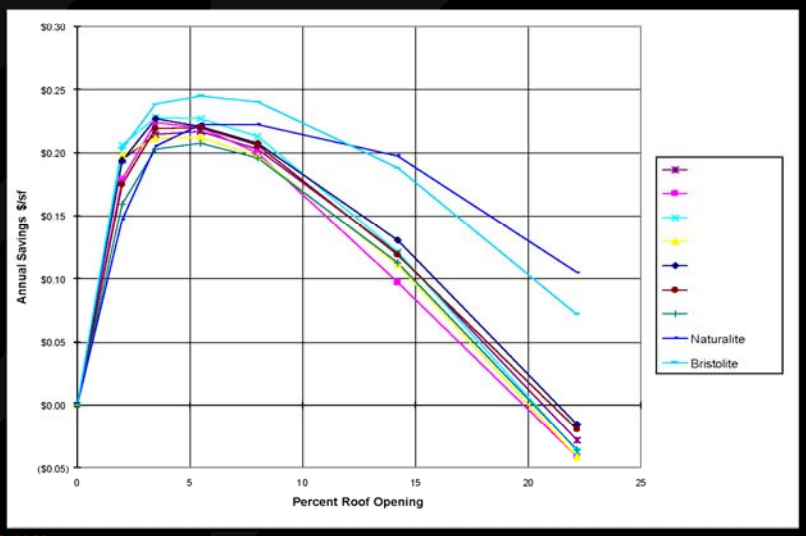
Building Energy Performance
Through Advanced Technologies …

Total Annual Savings vs. Roof Opening
Boston



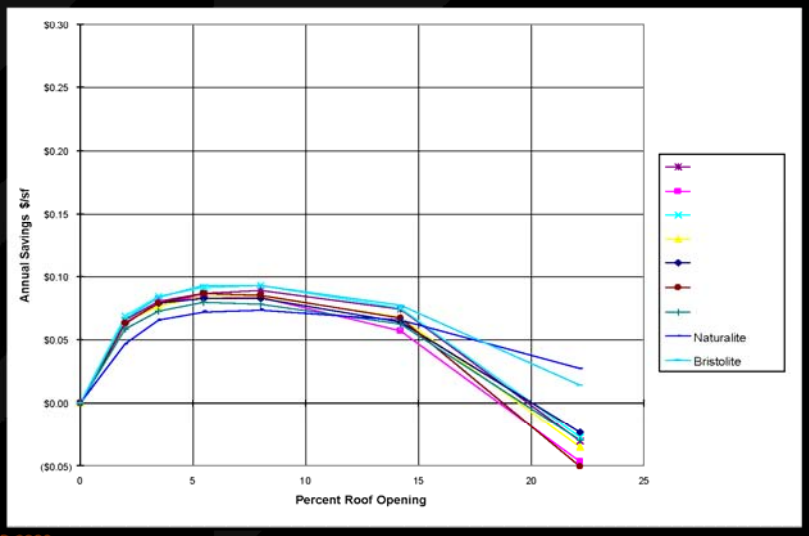
Building Energy Performance
Through Advanced Technologies …

Total Annual Savings vs. Roof Opening
Phoenix



Building Energy Performance
Through Advanced Technologies …

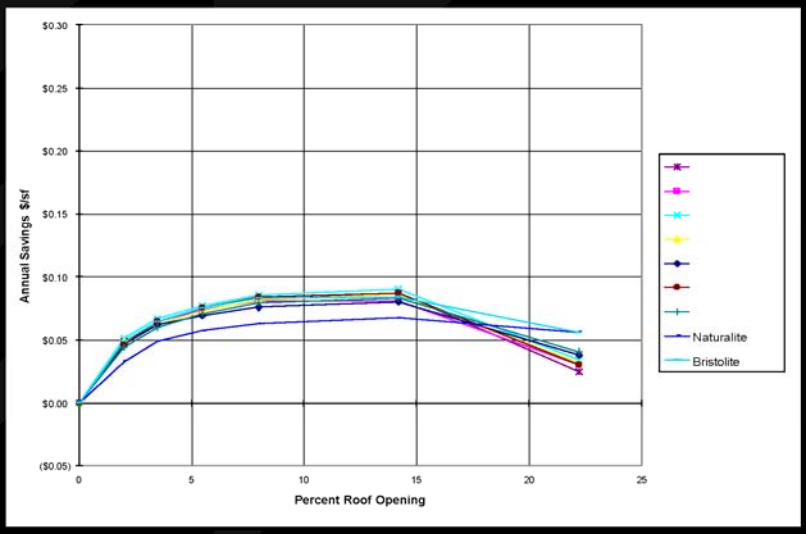
Total Annual Savings vs. Roof Opening
Minneapolis



Building Energy Performance
Through Advanced Technologies …

Total Annual Savings vs. Roof Opening

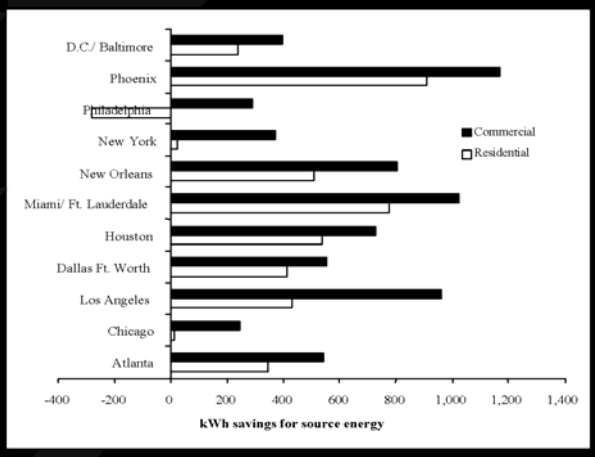
Seattle



Building Energy Performance
Through Advanced Technologies …

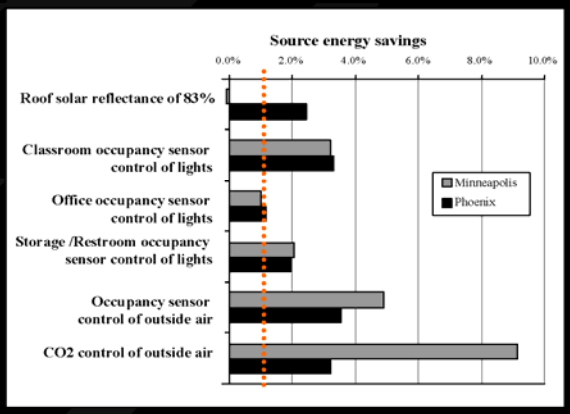
Highly Reflective Roofs and Annual Energy Savings

Source Energy Savings in kWh per 100m2 of light colored roof application based on data from Akbari and Konopacki (1998).



Building Energy Performance
Through Advanced Technologies ...

Highly Reflective Roofs Compared to Other Strategies



Source: The Weidt Group

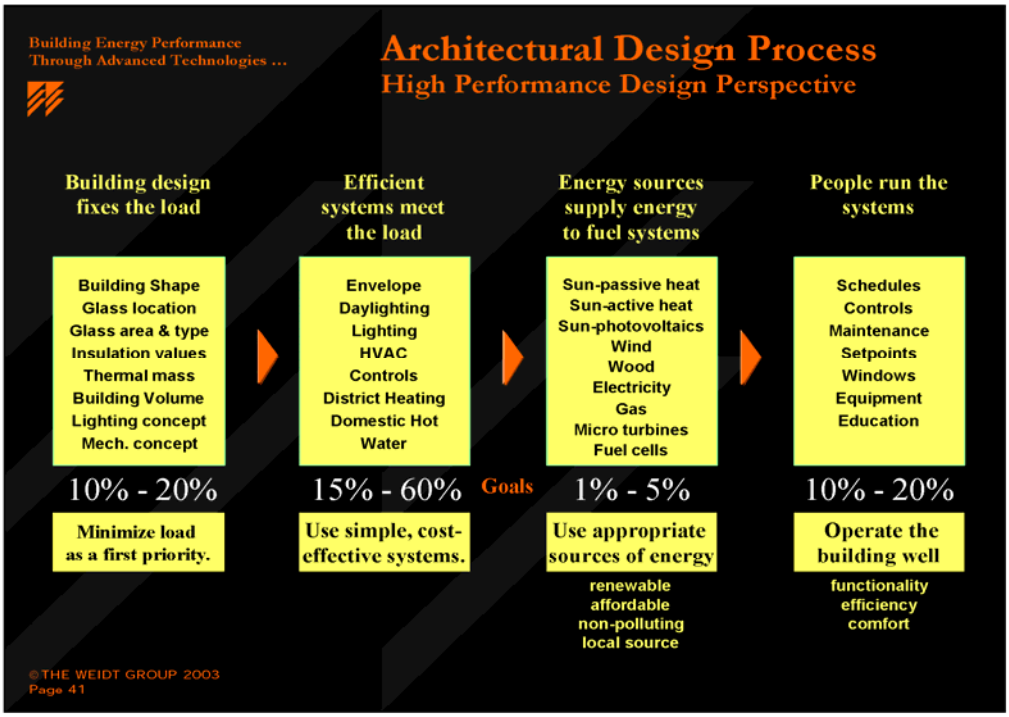
Building Energy Performance
Through Advanced Technologies ...

Elements of Past Successes

The greatest obstacle to discovery is not ignorance—it is the illusion of knowledge.

- Daniel J Boorstin

- **Groups make decisions that they can stick with and will repeat when the individuals involved**
  - Are confident in the process
  - Are respected for their expertise
  - Are presented an appropriate number of variables in an appropriate sequence
  - Are allowed to contrast and compare solutions early in decision making
  - Are able to verify their decisions through successive design and construction phases


Building Energy Performance
Through Advanced Technologies ...
Architectural Design Process
High Performance Design Perspective
Building design fixes the load
Efficient systems meet the load
Energy sources supply energy to fuel systems
People run the systems
Building Shape
Glass location
Glass area & type
Insulation values
Thermal mass
Building Volume
Lighting concept
Mech. concept
Envelope
Daylighting
Lighting
HVAC
Controls
District Heating
Domestic Hot Water
Sun-passive heat
Sun-active heat
Sun-photovoltaics
Wind
Wood
Electricity
Gas
Micro turbines
Fuel cells
Schedules
Controls
Maintenance
Setpoints
Windows
Equipment
Education
10% - 20%
15% - 60%
Goals
1% - 5%
10% - 20%
Minimize load as a first priority.
Use simple, cost-effective systems.
Use appropriate sources of energy
renewable
affordable
non-polluting
local source
Operate the building well
functionality
efficiency
comfort
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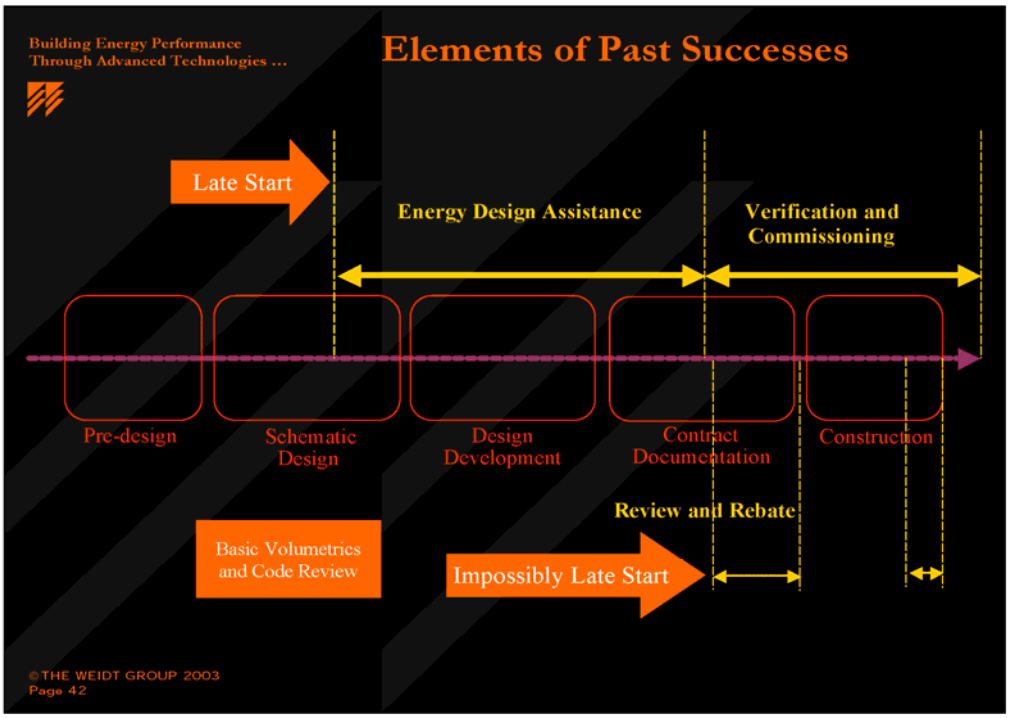
Building Energy Performance
Through Advanced Technologies ...
Elements of Past Successes
Late Start
Energy Design Assistance
Verification and Commissioning
Pre-design
Schematic Design
Design Development
Contract Documentation
Construction
Review and Rebate
Basic Volumetrics and Code Review
Impossibly Late Start
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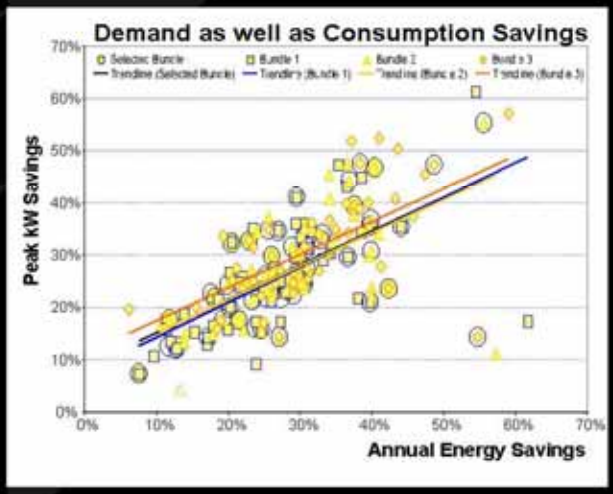
Building Energy Performance Through Advanced Technologies ...

Elements of Past Successes
Program Performance Metrics

Primarily a conservation program, the energy savings strategies proposed through the design assistance address electric peak, electric consumption, as well as natural gas and other fuels.

Bundles of strategies for all projects show comparable savings for energy consumption and peak demand.



Building Energy Performance Through Advanced Technologies ...

Elements of Past Successes
Program Performance Metrics

EDA Approach

The design team and owner retain creative control of solutions; and budget.

- Provide energy design feedback to architect/engineers
- Support decision-making with timely computer modeling
- Everyone clearly understands energy opportunities
- Support the development of appropriate, cost-effective energy strategies
- Provide financial incentives for those strategies
- Verify that strategies are in place and operating well

Building Energy Performance
Through Advanced Technologies …

Elements of Past Successes

Relationship Based Decision Making

Introductory Meeting

- Review building design
- Review building characteristics
- Review preliminary strategy list

Building Characteristics Confirmation

- Design drawings - CAD Files
- BC Form 1 (Envelope / Operating Characteristics)
- BC Form 2 (Mechanical / Plant Characteristics)

Strategy List Refinement

- Send revised strategy list descriptions

DOE 2.1E computer models

- Code base model
- 10 strategy groups (approx. 75 strategies)

Cost Analysis

- Send detailed strategy information
- Cost analysis (Design Team)

Bundle Meeting

- Review strategy results & costs, and assemble 3 bundles

Final Meeting

- Proposes incentives based on bundle simulations
- Introduce verification and validation process

Verification/Validation Process

- Owner agrees to implement one bundle
- Construction documents reviewed for strategies
- Field visits to verify strategies installed and working.

Building Energy Performance
Through Advanced Technologies …

Program cost-effectiveness

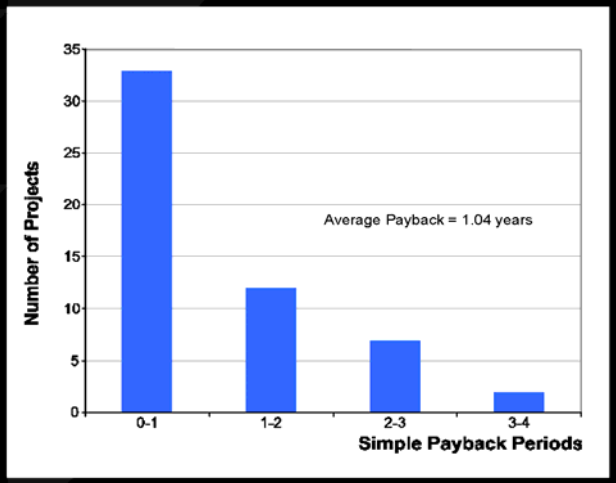
Paybacks Ranges

Paybacks Averages are Low but Vary from 1.04 to 1.20 Years

The payback period averages range based on building type, sample size, sample time and market conditions.

Paybacks shown here are calculated without incentive money from a utility company.

Paybacks for a selected bundle are calculated for its incremental cost and energy savings compared to a cost base design.

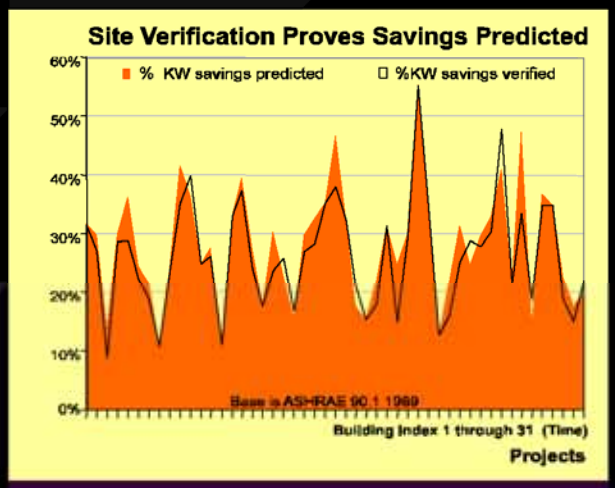


Building Energy Performance
Through Advanced Technologies …

ECEEE

During verification, an average of 94% of the peak kW savings predicted in the modeling are confirmed.

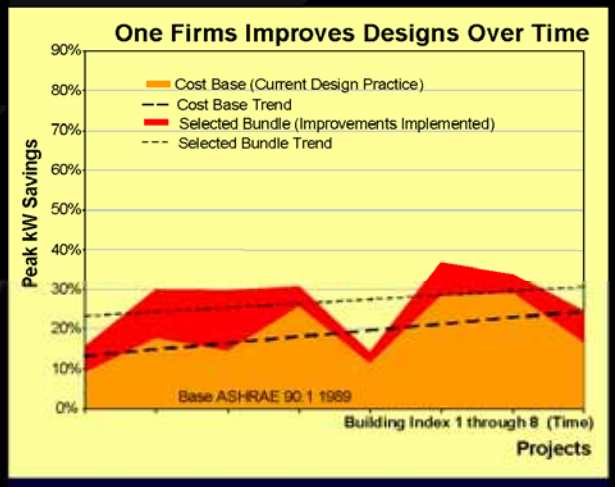
2001 Winner



Building Energy Performance
Through Advanced Technologies …

Design firms that have participated more often show a more significant improvement in their cost base designs. This tends to be the larger, more competitive firms.

2001 Winner

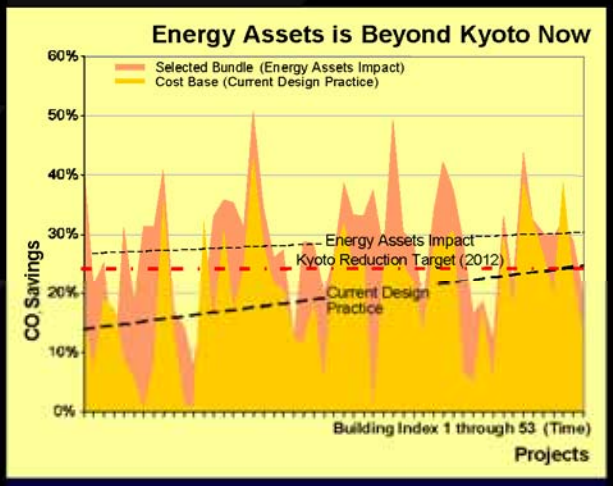


7% vs. 4%

Building Energy Performance
Through Advanced Technologies …

Commercial floorspace is projected to grow by 1% per year through 2010. A 7% reduction from 1990 levels then requires a 25% reduction in 2012. The Energy Assets Program records an increasing trend in CO2 reduction (with a program average of 31%) raising the Current Design practice levels beyond 25% by 2000.

2001 Winner



Building Energy Performance
Through Advanced Technologies …

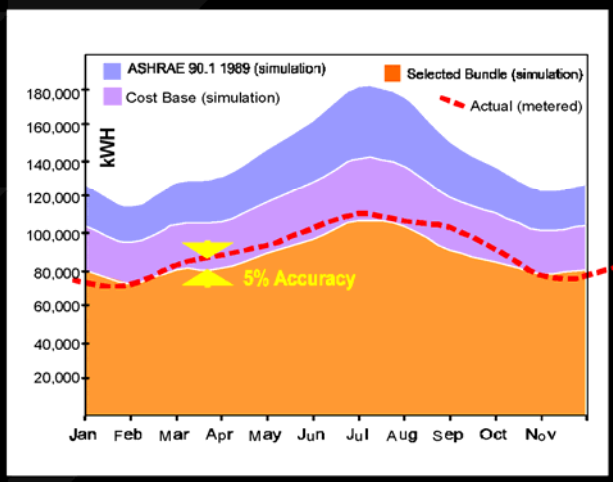
Program cost-effectiveness

Implementation

Spot Checks of Long-term Performance Indicates Effectiveness

Modeling assumptions and results are validated through continuous monitoring.

Monthly metered data for buildings that are operated as initially described by the building owners, matches closely with modeling predictions.



Building Energy Performance
Through Advanced Technologies …

Program Market Share

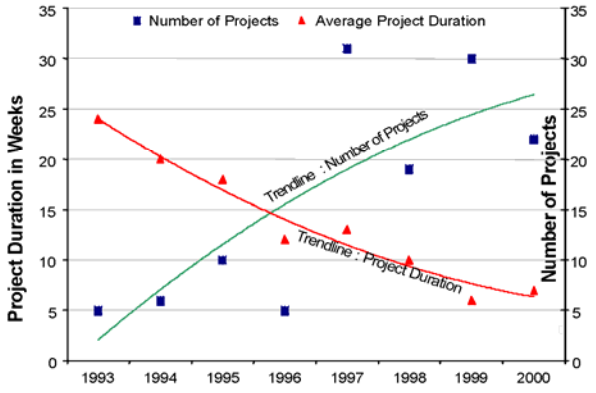
Market Segmentation and Penetration

Less Time More Influence

Increasing number of buildings

Decreasing consulting time

- Decreased from 6 months in 1993 to about 6 weeks in the year 2000 and even shorter soon.



Building Energy Performance
Through Advanced Technologies …

Outline

- Who we are
- Rules and Practice
- Failure and Success
- Examples

Building Energy Performance Through Advanced Technologies ...

IAMU by RDG with The Weidt Group

Elements of Past Successes
Market Segmentation and Penetration

- 80% of architectural firms that have participated, have participated at least twice
- 70% of architectural firms that have participated, have participated more than 3 times.
- The Design Assistance service has influenced design and owner communities to raise baseline designs.

Building Energy Performance Through Advanced Technologies ...

IAMU by RDG with The Weidt Group

Oberlin College by Others

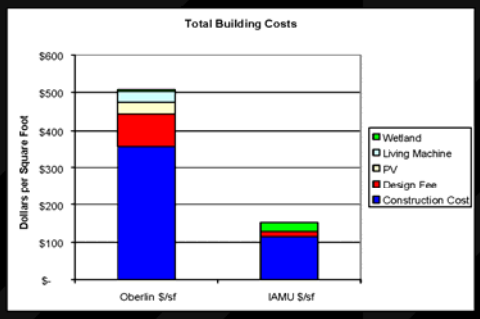
Elements of Past Successes
Program cost-effectiveness

- It depends on how the Base is set…
- Trade-offs: modeling is critical to the "value engineering" process
- Payback for modeling services is measured in weeks or months on most projects

Building Energy Performance Through Advanced Technologies …

Program cost-effectiveness

Do advanced building practices always increase construction costs?

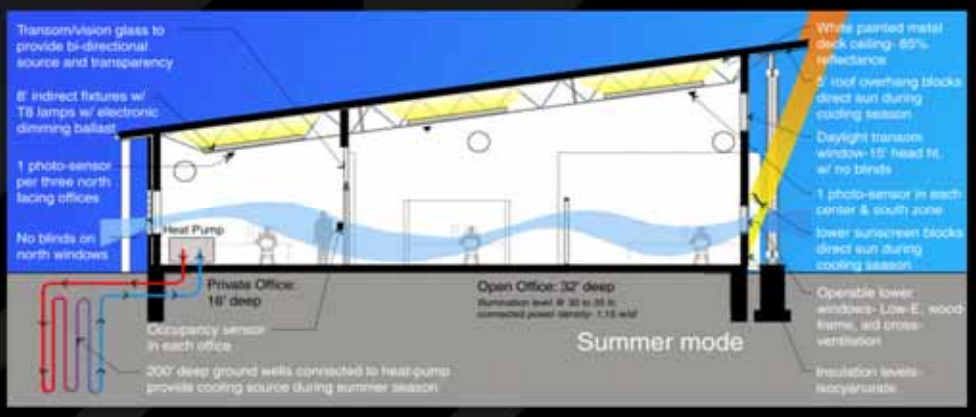


IAMU building has a 30% lower energy load due to building design after adjusting for climate and building type

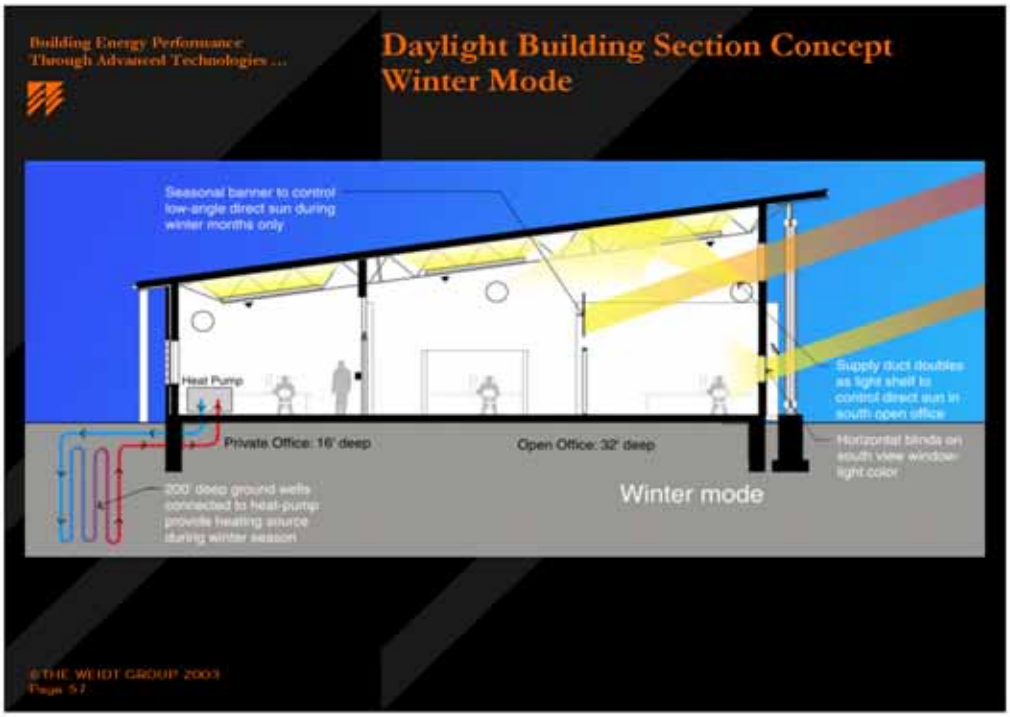
- Oberlin cost nearly 3.5 times IAMU to build
- Construction costs were 3 times that of IAMU
- Design fees were over 7 times those of IAMU
- The performance of Oberlin was, even with compromised operation, about equal to IAMU at about 30 Kbtu/SF/Yr including equipment loads

Building Energy Performance Through Advanced Technologies …

Daylight Building Section Concept Summer Mode



Iowa Association of Municipal Utilities Architects - RDG


Building Energy Performance
Through Advanced Technologies ...
Daylight Building Section Concept
Winter Mode
Seasonal banner to control
low-angle direct sun during
winter months only
Heat Pump
Supply duct doubles
as light shelf to
control direct sun in
south open office
Private Office: 16' deep
Open Office: 32' deep
Horizontal blinds on
south view window:
light color
200' deep ground wells
connected to heat-pump
provide heating source
during winter season
Winter mode
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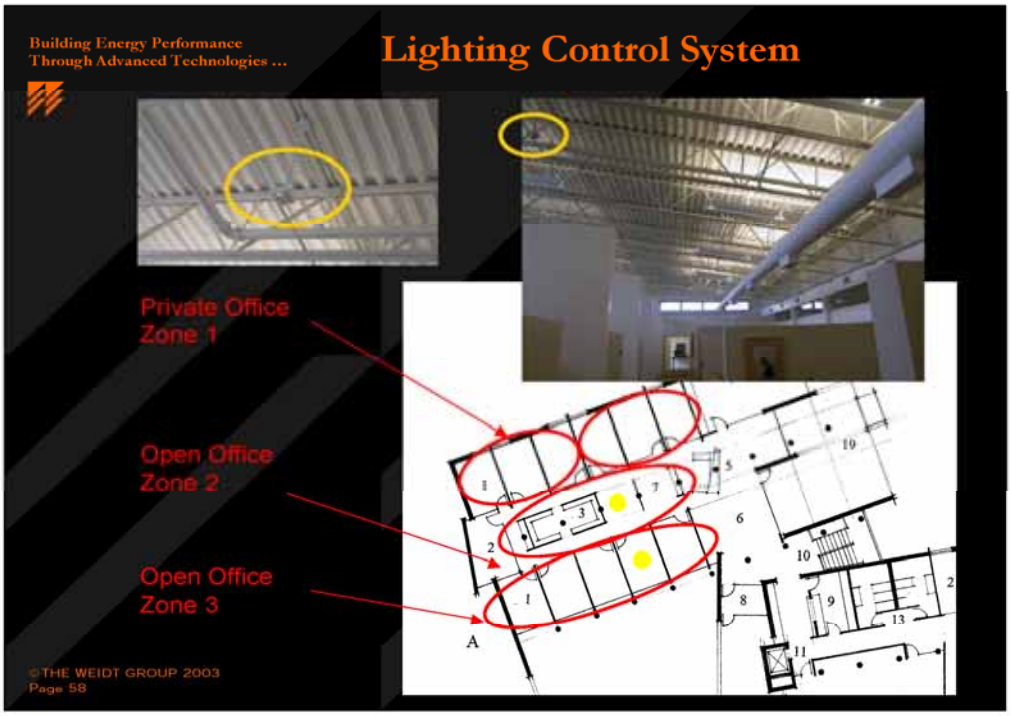
Building Energy Performance
Through Advanced Technologies ...
Lighting Control System
Private Office
Zone 1
Open Office
Zone 2
Open Office
Zone 3
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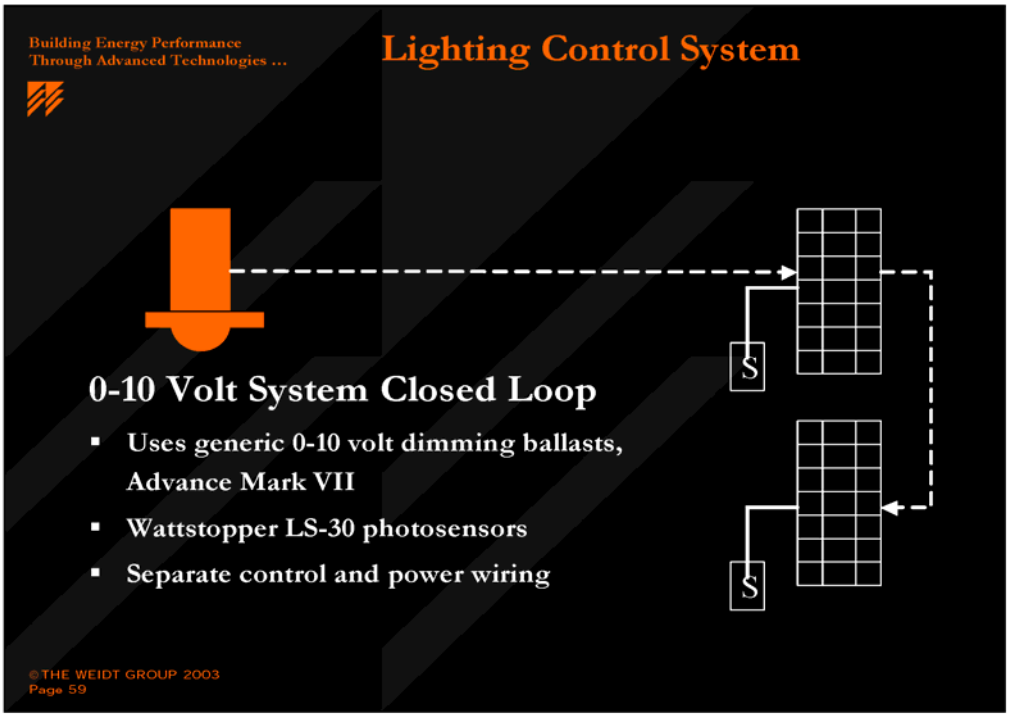
Building Energy Performance
Through Advanced Technologies ...
Lighting Control System
0-10 Volt System Closed Loop
Uses generic 0-10 volt dimming ballasts, Advance Mark VII
Wattstopper LS-30 photosensors
Separate control and power wiring
S
S
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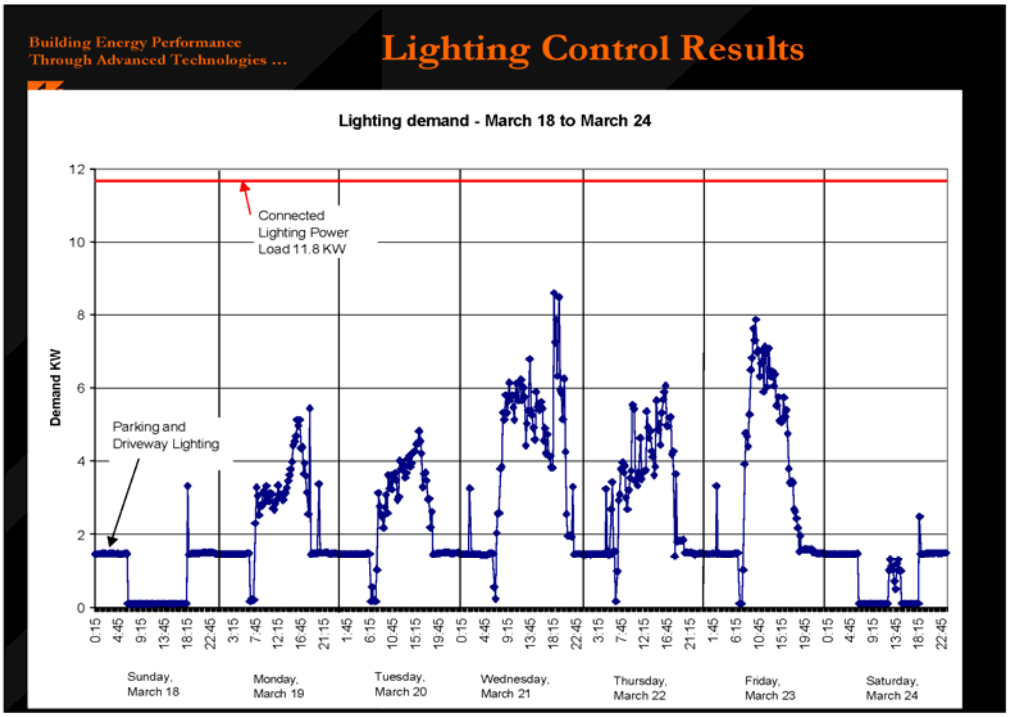
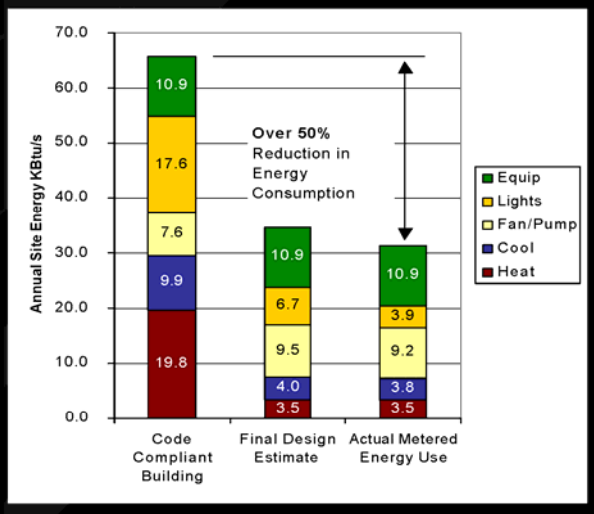
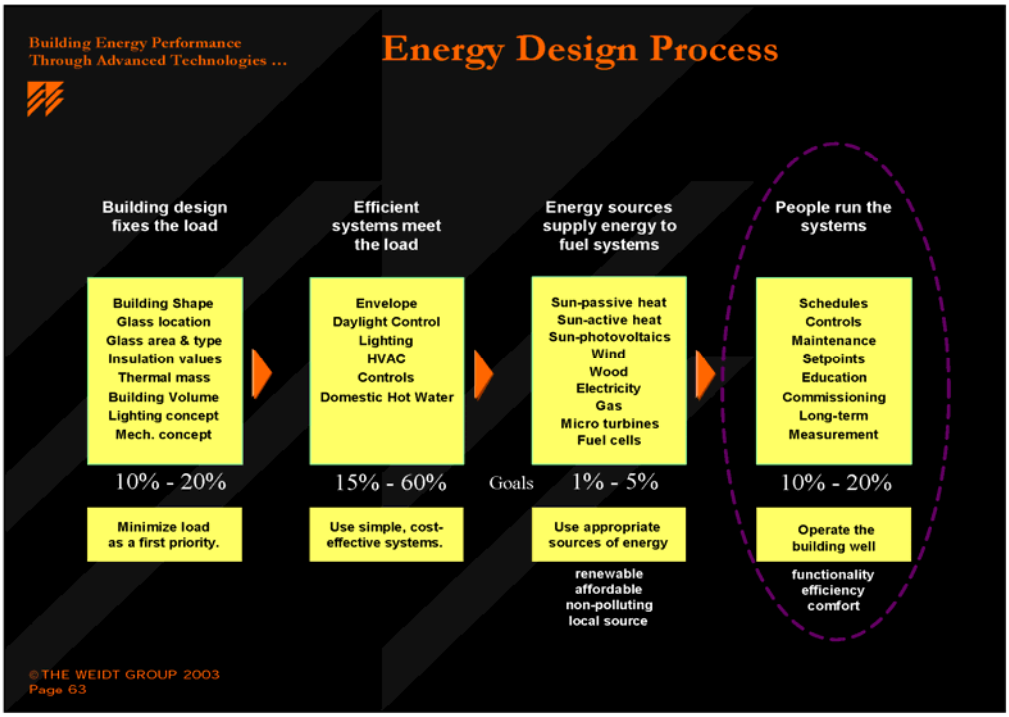

Building Energy Performance
Through Advanced Technologies ...
Lighting Control Results
Lighting demand - March 18 to March 24
Demand KW
Connected Lighting Power Load 11.8 KW
Parking and Driveway Lighting
Sunday, March 18
Monday, March 19
Tuesday, March 20
Wednesday, March 21
Thursday, March 22
Friday, March 23
Saturday, March 24

Building Energy Performance
Through Advanced Technologies ...

Actual Energy Performance

- Actual Energy Performance has been 10% lower than estimates
- Long term building environmental and energy monitoring are being performed to further evaluate and improve the building's operation.




Building Energy Performance
Through Advanced Technologies ...
Energy Design Process
Building design fixes the load
Efficient systems meet the load
Energy sources supply energy to fuel systems
People run the systems
Building Shape
Glass location
Glass area & type
Insulation values
Thermal mass
Building Volume
Lighting concept
Mech. concept
Envelope
Daylight Control
Lighting
HVAC
Controls
Domestic Hot Water
Sun-passive heat
Sun-active heat
Sun-photovoltaics
Wind
Wood
Electricity
Gas
Micro turbines
Fuel cells
Schedules
Controls
Maintenance
Setpoints
Education
Commissioning
Long-term
Measurement
10% - 20%
15% - 60%
Goals
1% - 5%
10% - 20%
Minimize load as a first priority.
Use simple, cost-effective systems.
Use appropriate sources of energy
renewable
affordable
non-polluting
local source
Operate the building well
functionality
efficiency
comfort
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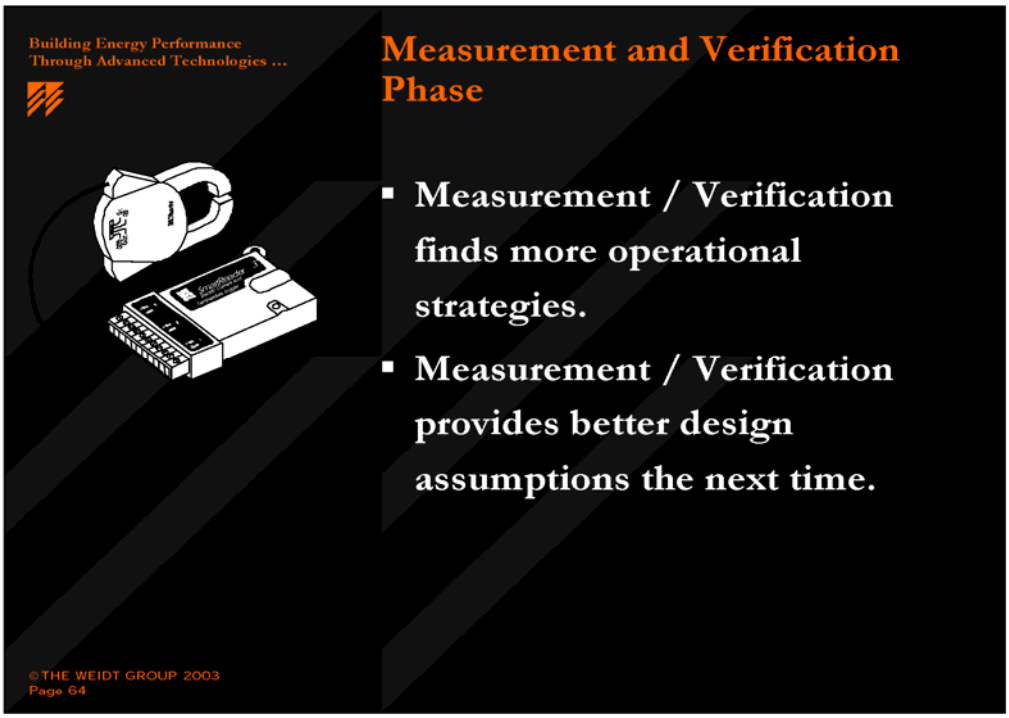
Building Energy Performance
Through Advanced Technologies ...
Measurement and Verification Phase
Measurement / Verification finds more operational strategies.
Measurement / Verification provides better design assumptions the next time.
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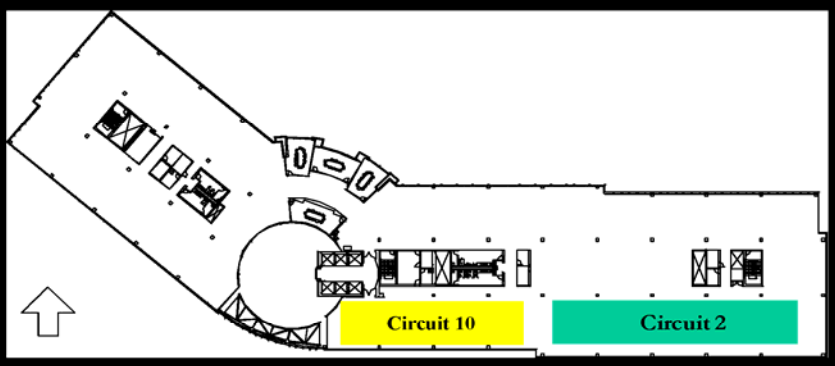
Building Energy Performance
Through Advanced Technologies …

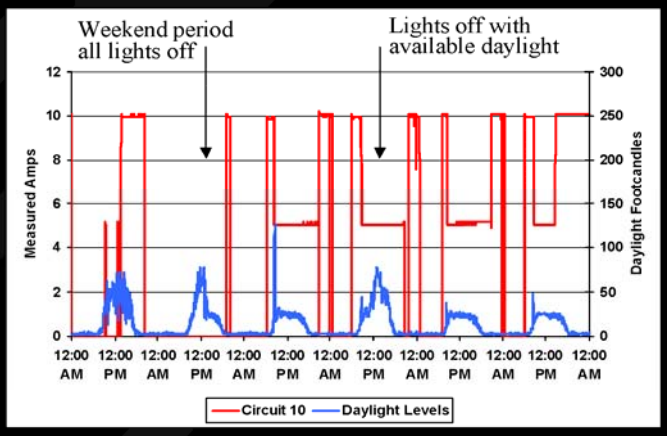
Sidelighting Results
Photo Sensor Controlled
Stepped Daylighting



Building Energy Performance
Through Advanced Technologies …

Sidelighting Results
Photo Sensor Controlled
Stepped Daylighting

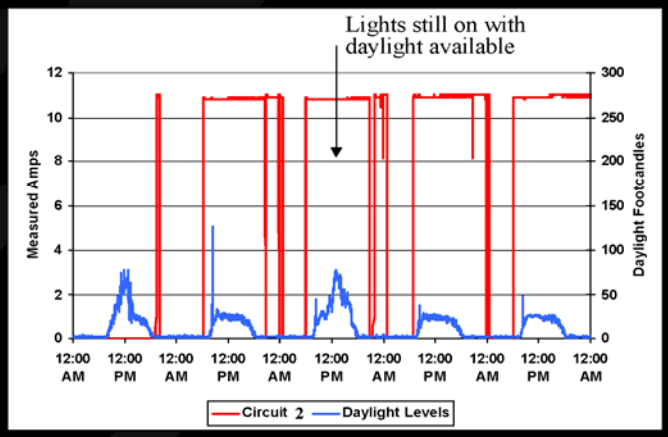
1. Only Half of Fixtures are on Daylighting Controlled Circuit
2. Controlled Fixtures are working as expected



Building Energy Performance
Through Advanced Technologies …

Sidelighting Results
Photo Sensor Controlled
Stepped Daylighting

- Same controls as before
- Same building different floor
- Sensors not calibrated to step down lights



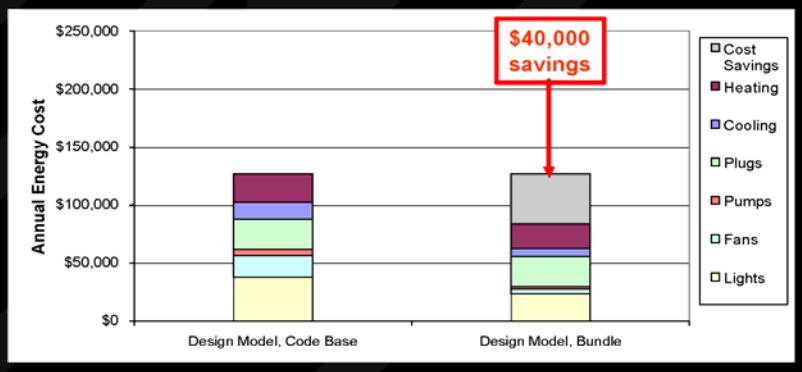
Building Energy Performance
Through Advanced Technologies …

The Impact of Operations

- 90,000 s.f. office building
  - Designed with efficient lighting, fans, chillers, controls

Building Energy Performance
Through Advanced Technologies …

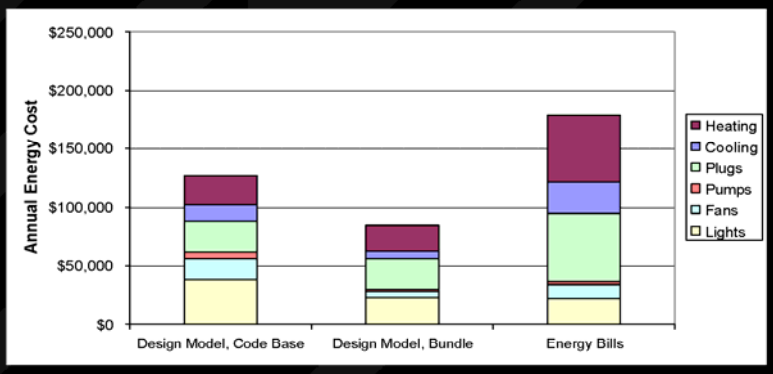
Impact of Operations:
90,000 s.f. office building



Building Energy Performance
Through Advanced Technologies …

Impact of Operations:
90,000 s.f. office building

- After one-year operation



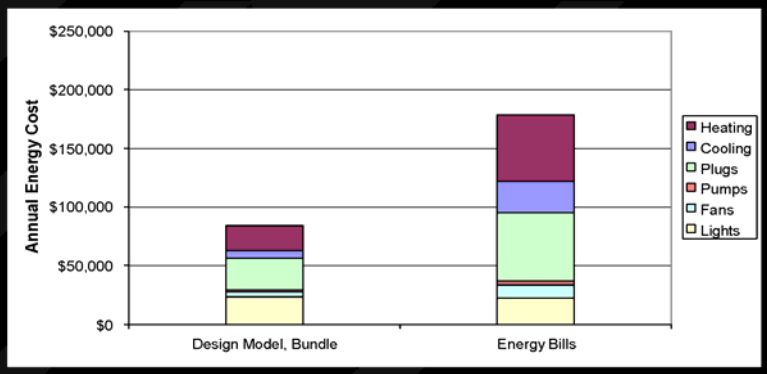
Building Energy Performance
Through Advanced Technologies ...

Impact of Operations: 90,000 s.f. office building

- **Can we model the impact of these design / operational changes?**
  - Yes, through detailed measurement during occupancy.
  - A quick investigation accounts for 80% of the difference.
- **What happened?**
  - Added 24/7 web-site and call center operation
  - Added second shift and two-shift copy center
  - Mechanical controls settings not as efficient as modeled

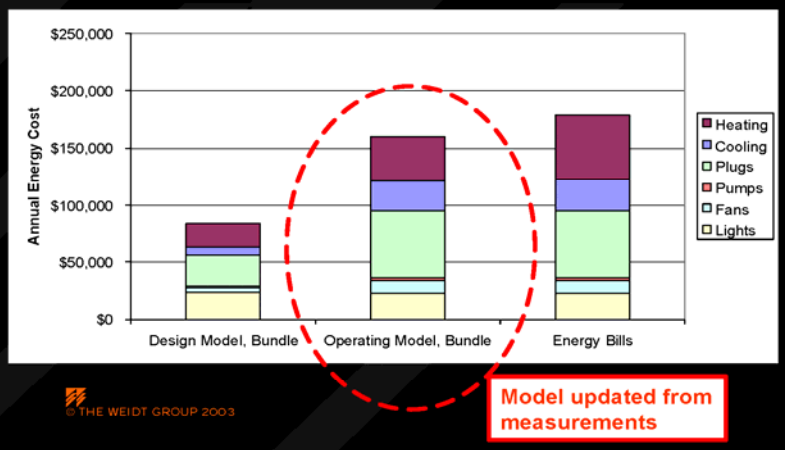
Building Energy Performance
Through Advanced Technologies ...

Impact of Operations: 90,000 s.f. office building



Building Energy Performance
Through Advanced Technologies ...

Impact of Operations: 90,000 s.f. office building



Model updated from measurements

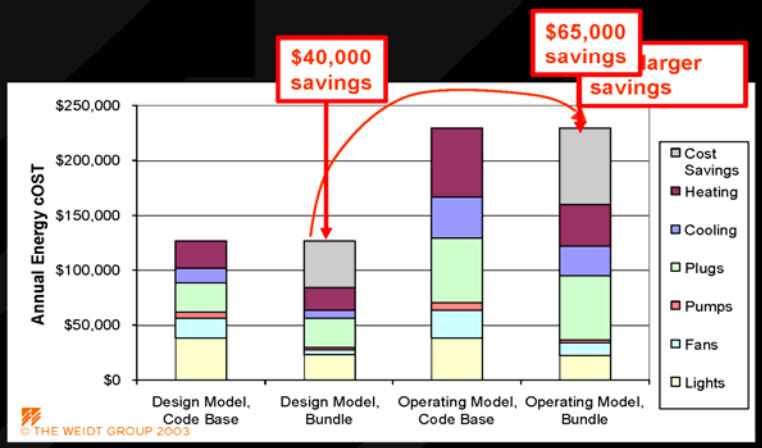
Building Energy Performance
Through Advanced Technologies ...

Impact of Operations:
90,000 s.f. office building

- How does the operational change affect the energy savings?
- Typically, more hours of operation means more energy savings.

Building Energy Performance
Through Advanced Technologies …

Impact of Operations:
90,000 s.f. office building



- *How does the operational change affect the energy cost savings?*
- Typically, more hours of operation means more energy savings.

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